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DEVELOPMENT AND MAINTENANCE OF TYPICAL NAVIGATION CHANNEL, RED --ETC(U)
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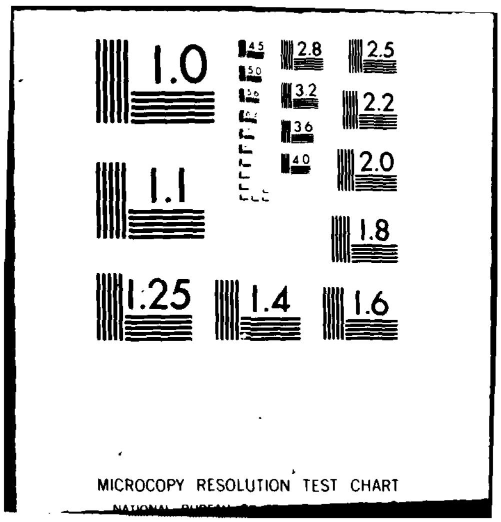
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TECHNICAL REPORT HL-82-6

DEVELOPMENT AND MAINTENANCE OF TYPICAL NAVIGATION CHANNEL, RED RIVER

Hydraulic Model Investigation

by

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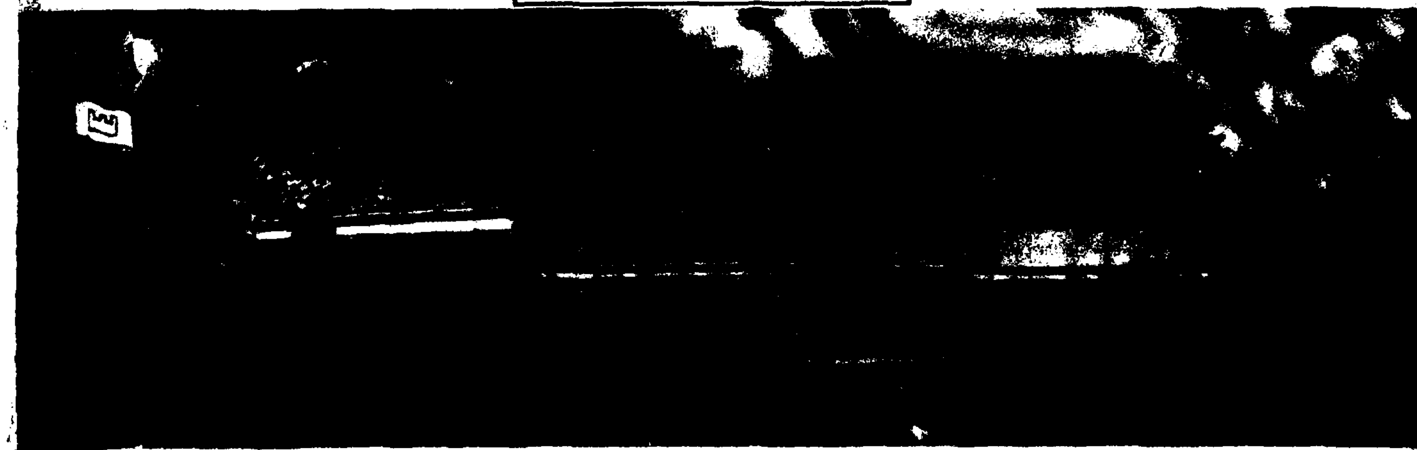
February 1982
Final Report



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The Red River between miles 68.6 and 79.2 was selected as a typical troublesome reach in which to determine the general channel realignment, training, and stabilization structures necessary to provide a navigation channel of adequate depth and width that would be stable and require minimum dredging.

The movable-bed model was built to a horizontal scale of 1:150 and a vertical scale of 1:100.

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20. ABSTRACT (Continued).

The following conclusions were indicated by the model investigation:

a. The natural channel of the Red River and typical cross sections proposed for cutoffs were too wide to provide adequate navigation channel depths without contraction and stabilization structures.

b. Considerably more length of dike was required to maintain an adequate navigation channel when the existing river alignment was followed than when an improved channel alignment was used.

c. Preservation of old bendways created by channel realignment was substantially improved by a closure of the upper end to top bank elevation and the construction of structures designed to block movement of sediment-carrying bottom currents entering the lower end of the channel.

PREFACE

This model investigation was conducted for the U. S. Army Engineer District, New Orleans (LMN) by the U. S. Army Engineer Waterways Experiment Station (WES) during the period October 1971 to January 1976. The study was authorized by the Office, Chief of Engineers (OCE), U. S. Army, in a teletype message dated 11 December 1970 and by LMN Work Orders dated December 1970 to July 1975.

During the model study, the Lower Mississippi Valley Division (LMVD) and LMN were kept informed of the progress of the study through monthly progress reports, periodic transmittal of preliminary results, and interim reports of special tests. In addition, Messrs. Sam Powell and Bruce McCartney of OCE; A. J. Davis, Raymond Haas, Ernest Lipscomb, Estes Walker, and Max Lamb of LMVD; Bill Garrett, Jack Bardwell, Jim Austin, G. T. Brantley, W. J. Beerli, and Allen Coates of LMN visited WES during the course of the study to observe tests in progress and discuss test results.

The investigation was conducted in the Hydraulics Laboratory under the general supervision of Messrs. H. B. Simmons, Chief of the Hydraulics Laboratory, and F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory; and under the direct supervision of Messrs. J. J. Franco (retired) and J. E. Glover, Chiefs of the Waterways Division. The engineers in immediate charge of the model were Messrs. C. D. McKellar, Jr. (retired), and J. E. Foster (retired), Chiefs of the River Regulation Branch, who were assisted by Messrs. C. R. O'Dell, A. I. Fortenberry, J. A. Holliday, and H. S. Headley III. This report was prepared by Messrs. Foster, O'Dell, and Franco.

Commanders and Directors during the course of this investigation and the preparation and publication of this report were BG E. D. Peixotto, CE, COL G. H. Hilt, CE, COL John L. Cannon, CE, COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres

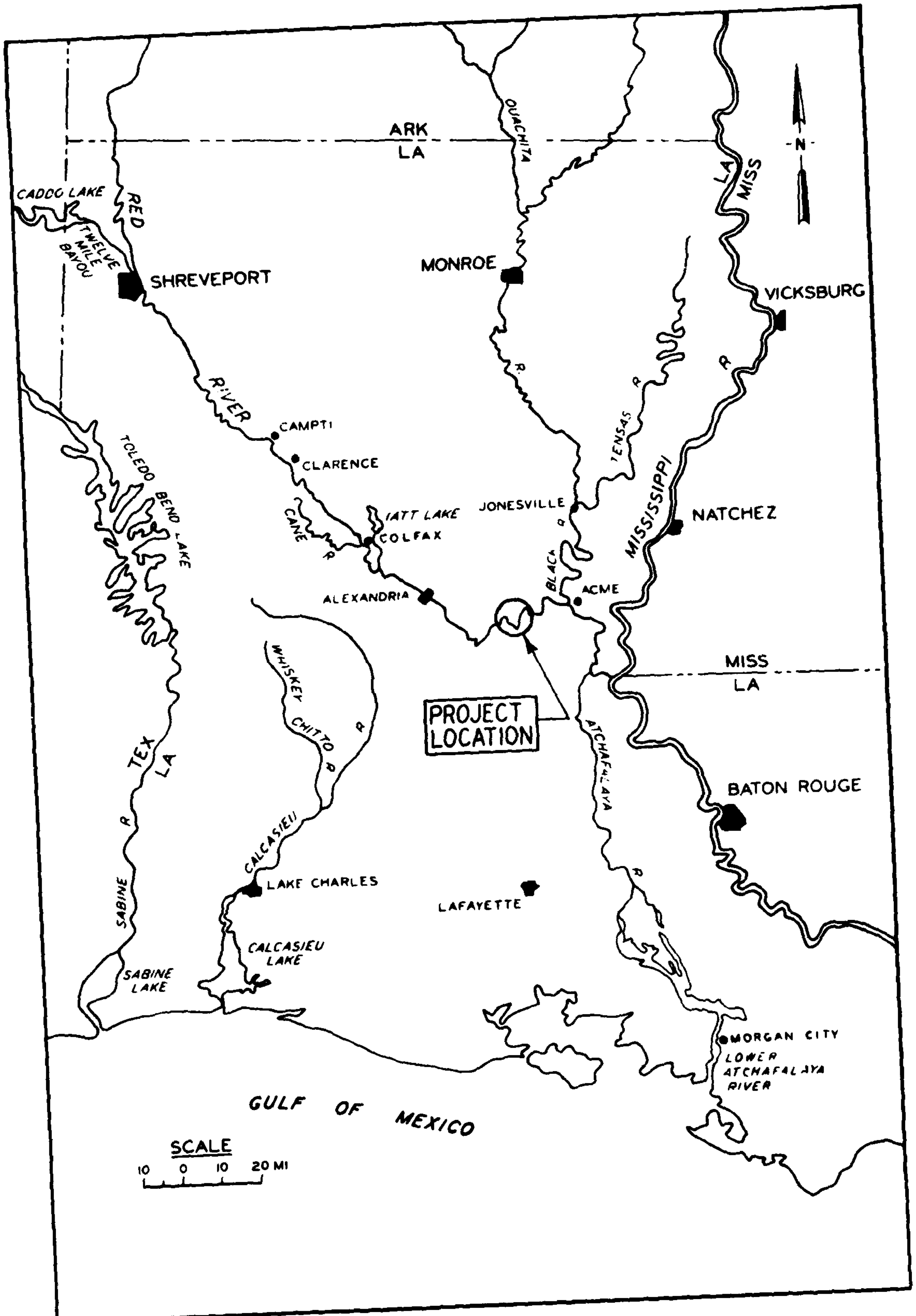

Figure 1. Location map

DEVELOPMENT AND MAINTENANCE OF TYPICAL NAVIGATION CHANNEL, RED RIVER

Hydraulic Model Investigation

PART I: INTRODUCTION

Location and Description of Prototype

1. The Red River (Figure 1) flows easterly from the northwest portion of Texas, along the border between Texas and Oklahoma into southwestern Arkansas where it turns southeasterly to flow through the northwestern portion of Louisiana to Shreveport and then easterly to join the Old River and form the Atchafalaya River. The Atchafalaya River flows through the southeastern portion of Louisiana to the Gulf of Mexico downstream of Morgan City, Louisiana. Flow in the upper portion of the Red River is controlled by releases from Denison Dam, which is located on the Texas-Oklahoma State line. Flow from the Mississippi River through the Old River has considerable backwater effect on stages in the lower portion of the Red River.

2. The Red River is characterized by large fluctuations in stage, shifting bed and banks, and unpredictable shoaling. Controlling depths in the Red River have averaged about 6 ft* from the mouth to Alexandria and about 5 ft from Alexandria to Shreveport during the period January to July and generally less than this during the remainder of the year. The controlling depths during some periods are as low as 1 to 2 ft in the Alexandria to Shreveport reach. Due to long periods of low flows, narrow bends of short radii, and a heavy sediment load, the use of the Red River for movement of cargo by barges has been limited.

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

Present Plan of Development

3. On 13 August 1968, the 90th Congress authorized the development of the Red River Waterway Project with the passage of Public Law 90-483. As presently authorized, the Red River multipurpose project provides for the improvement of the Red River and its tributaries in Louisiana, Arkansas, Texas, and Oklahoma through coordinated development to serve nagivation, bank stabilization, flood control, recreation, fish and wildlife, and water quality control. The primary function of the project is to provide for establishing a navigation channel approximately 305 miles long, 9 ft deep, and 200 ft wide from the vicinity of the Old River to Lake of the Pines near Dangerfield, Texas, by a system of nine locks and dams, extensive channel realignment, a number of cutoffs, and miles of channel training and stabilization works. The project consists of four distinct reaches: (a) Mississippi River to Shreveport, Louisiana; (b) Shreveport to Dangerfield, Texas, by Twelve Mile Bayou; (c) Shreveport to Index, Arkansas; (d) Index to Denison Dam, Texas.

4. The Appropriations Act of 1971, approved 7 October 1970 as Public Law 91-439, provides the authority to initiate preconstruction planning from the Mississippi River to Shreveport.

Need for and Purpose of Model Study

5. The successful canalization of the Red River will require solutions to many channel development and maintenance problems. Analytical solutions to these problems on a river, heavily laden with sediment, are complex and uncertain. Therefore, a hydraulic movable-bed model of a typical reach of the river was considered necessary to determine some of the problems involved, the effects of various types of training structures, and improvement plans and to provide some general information that could be used in the solution of problems in other reaches. The specific purposes of the investigation were to determine the most effective type or types of dikes and dike systems required to improve channel depth and width under various conditions, method and structures

required for the development of cutoffs, and structures required to maintain access to the old bendway for navigation and recreation.

PART II: THE MODEL

Description

6. In order to obtain some general information that would be applicable to other reaches of the river, a typical troublesome reach was selected for this study in conference with representatives of the Lower Mississippi Valley Division and the U. S. Army Engineer District, New Orleans (LMN). The reach selected was between miles 68.6 and 79.2* (Figure 2). This reach would require some channel realignment and considerable channel training and stabilization structures with the possibility of a bend cutoff (Figure 3). The reach would be in the upstream end of a pool that would be created by a proposed lock and dam structure where the depth of water would be minimum and most of the problems would be encountered.

7. The model of this reach was constructed in a large flume that could also be used for the study of other reaches that might be required. The model was of the movable-bed type with a horizontal scale of 1:150 and a vertical scale of 1:100. The banks and overbank areas were constructed of loose gravel to facilitate changes. Sheet-metal seals were installed at intervals in the overbank areas to eliminate seepage through the loose gravel. The bed of the model channel was reproduced in crushed coal. Stone dikes were reproduced with crushed stone and pile dikes were simulated with rows of metal rods.

8. Initially, the model channel bed was molded to the configurations indicated by the prototype hydrographic survey of 8-15 April 1968, as shown in Plates 1 and 2. Overbank areas were molded to the contours and elevations indicated by the latest available maps and charts.

Appurtenances

9. Water was supplied to the model by means of a 10-cfs axial flow pump located in a circulating system. Discharge was controlled and

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* Miles are river miles above the confluence of the Red and Old Rivers.

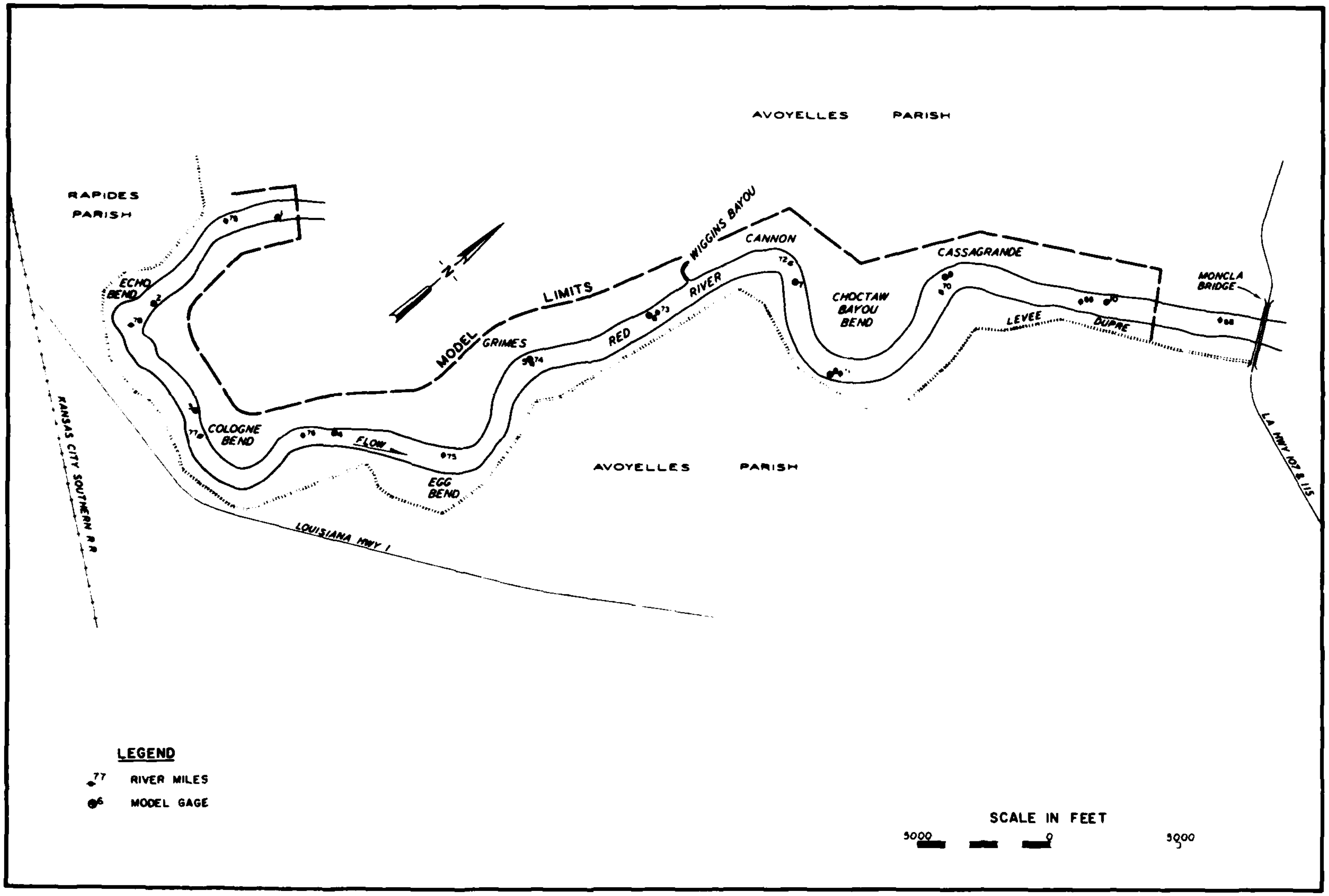

Figure 2. Model layout and gage location

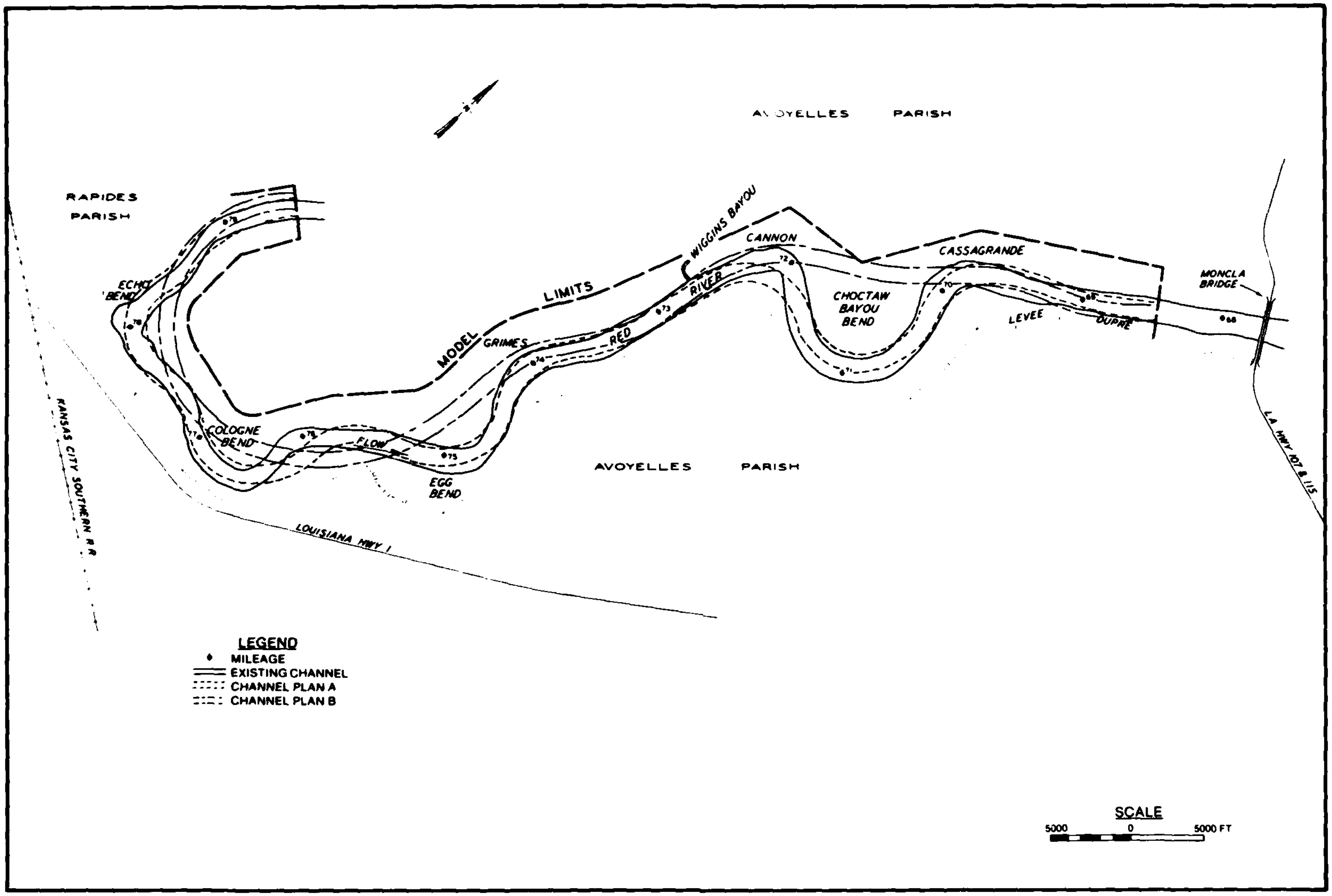

Figure 3. Channel alignment

measured by means of a valve and a venturi meter located near the upper end of the model. Water-surface elevations were measured along the model channel by means of 10 point gages located as shown in Figure 2. Tailwater elevations based on a rating curve furnished for the purpose were controlled by means of a tailgate located at the lower end of the model. Horizontal and vertical controls were maintained by means of graded rails established along each side of the channel. Bed material introduced at the upper end of the model and that extruded from the lower end were measured by means of a graduated container.

Model Adjustment

10. Before tests of improvement plans are undertaken on a movable-bed model, the reliability and accuracy with which the model reproduces prototype conditions are usually established through the process of model verification. This process involves adjustment of the various hydraulic forces, rates of introducing bed material, model operating technique, and other factors until the model demonstrates the ability to reproduce with reasonable accuracy the changes in bed configuration known to have occurred in the prototype between certain dates.

11. Since only one recent survey was available for the reach reproduced in this model, the conventional verification procedure was not possible for this study. However, some adjustment of the model was made starting with the available prototype survey and reproducing flow conditions that had occurred during the one-year period before the survey was made (Plate 3). Adjustments were continued until the model reproduced bed movement and channel configurations that could normally be expected in the Red River, based on an evaluation of the conditions indicated by the available prototype survey. This procedure assumes that there are no major changes in the river channel during the adjustment period.

12. A comparison of the model conditions resulting from the final adjustment test, shown in Plates 4 and 5, with the conditions indicated by the prototype survey (Plates 1 and 2) indicates that the model

reproduced the general characteristics of the prototype reach. Generally, the model channel tended to be somewhat deeper than that indicated by the prototype survey except in the upper bend where depths were from 3 to 5 ft less. Since this was to be a general study and the differences would be considered in the evaluation of the results of tests of the improvement plans, the adjustment was considered adequate for the purpose of this study. As a result of the adjustment the hydraulic scale relationship, time scale, and rate of introducing bed material were established and used in the tests of the improvement plans.

PART III: TESTS AND RESULTS

Test Procedure

13. In order to obtain some general information that could be used in other reaches of the river, three series of tests were conducted on the model. The first two series were designed to determine the structures required to develop a channel along each of two proposed alignments, Plans A and B (Figure 3). The third series, Plan C, was concerned with the development of a cutoff, its effect on channel development upstream and downstream, and the method of maintaining an entrance to the old bendway. Each series consisted of tests of the original plan as furnished by LMN and various modifications to improve the plan.

14. The plans and their modifications were tested by reproducing a yearly discharge hydrograph representative of Red River flows, introducing bed material to simulate bed material moving into the reach with each flow, and controlling water-surface elevations at the downstream end of the model to duplicate backwater effects from the river downstream. Initially, the yearly discharge hydrograph (furnished by LMN as typical for that reach of the Red River) was essentially the same as that recorded in the prototype during the period April 1967 to April 1968 (Plate 6). The sequence of some of the flows was changed for tests of the last modifications to Plan A and for tests of Plan B as shown in Plates 6 and 7. The rate of introducing bed material at the upper end of the model was the same as that required for model verification. Water-surface elevations were controlled at the downstream end of the model based on a rating curve submitted by LMN. The rating curve was based on the effects of proposed Lock and Dam 1 and anticipated channel modifications downstream of the model reach; thus, the test hydrograph was somewhat different than the adjustment hydrograph (see Plate 3). Each reproduction of the annual hydrograph is referred to as a "run." The bed of the model prior to the test of each plan or modification was molded either to a typical cross section furnished by LMN or to that obtained at the end of the preceding test. A number of modifications were tested

in each series, but only the significant results are presented in this report.

15. Developments in the reach were affected to a large extent by the effects of the proposed lock and dam downstream on water-surface elevations, particularly during the low flows. With the higher water-surface elevations during controlled flows, velocities would tend to be less than those without the lock and dam and the bed movement would be reduced. However, in the model tests the effect of the lock and dam on sediment storage upstream was not considered, and the rate of introduction of bed material was the same as that determined in the verification test without the structure.

Plan A

Description

16. Plan A, the initial plan proposed by LMN, consisted of a realigned channel generally within the existing bank lines, as shown in Figure 3. This plan involved the use of various types of dikes and revetted banks designed to increase the radius of bends to a minimum of 2600 ft and to eliminate shoaling in the crossings and some of the straight reaches. Dikes listed in Table 1 and shown in Plates 8 and 9 were generally 6 to 8 ft above normal pool elevation* in the upper reach of the model and from 4 to 6 ft above normal pool in the lower reach. The crest of the spur dikes generally sloped 2 ft from the bank to the channel end, and the crest of the L-head sections and the longitudinal dikes sloped from upstream to downstream as much as 10 ft. Baffle dikes were installed from the longitudinal dikes to the bank to prevent concentration of flow behind the longitudinal dikes when overtopped. The dikes were designed to provide a minimum controlled channel width of 480 ft at normal pool elevation. At the start of the test of this plan, the channel bed was molded to a typical cross section furnished by LMN and provided a continuous 9-ft navigation channel throughout the length of the model.

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* Normal pool elevation of proposed Lock and Dam 1 is 40 ft above NGVD.

Results

17. Results of tests of Plan A after three runs are shown in Plates 8 and 9 and indicate that considerable shoaling would occur in the upper reach, particularly through the first two bends, upstream of mile 78. Between miles 78 and 74, most of the crossings were less than project depth. A continuous channel of at least 9 ft was obtained through most of the reach downstream of mile 74, but the channels over some of the crossings were significantly less than the authorized 200-ft-wide navigation channel at 9-ft depth.

Plans A-1 Through A-11

18. Plans A-1 through A-11 were progressive modifications of Plan A designed to provide a satisfactory channel through the reach along the alignment used for Plan A. Modifications consisted of changes in the type, alignment, number, and elevations of dike structures based on results of tests of the preceding plan. Since tests of these plans were in the nature of preliminary tests during which a satisfactory channel had not developed through the entire reach, results are not included in this report.

Plan A-12

Description

19. Plan A-12 included modifications of Plan A, most of which were developed during the tests of Plans A-1 through A-11. The structures in this plan are shown on Plates 10 and 11 and listed in Table 1.

Results

20. Results of test of Plan A-12 after one reproduction of the typical hydrograph are shown in Plates 10 and 11. These results indicate that a continuous channel of at least 9 ft below normal pool elevation had developed through the entire reach. However, the width of the channel over some of the crossings, particularly in the upper reach, was limited. Considering the tendency of the model to be shallower than the

prototype, channel widths and depths with this plan should be adequate under the conditions tested.

Plan A-13

Description

21. Plan A-13 was the same as Plan A-12 except for modifications designed to improve channel width and alignment in Egg Bend and flow conditions through Choctaw Bend. Modifications shown in Plates 12 and 13 included the following:

- a. A spur dike was added along the right bank at mile 75.5 that was designed to reduce the tendency for the channel to develop away from the longitudinal dike on the opposite bank.
- b. The dikes along the right bank on the concave side of Choctaw Bend (mile 71) were modified to form a continuous longitudinal dike.

Results

22. Results of test of Plan A-13, shown in Plates 12 and 13, indicate adequate depths through the entire reach. There were some improvements in flow conditions and in the alignment and width of the channel, particularly in the vicinity of Egg Bend and Choctaw Bend where modifications in the dike structures were made.

Discussion of Test Results - Plan A

23. The alignment of the channel for Plan A was designed to follow the existing channel insofar as practical. The reach is characterized by sharp and irregular bends, some long relatively straight reaches, and some short crossings. Development of a satisfactory channel with this alignment involved the use of an unusually large number of structures of various types. The structures were designed to contract the channel sufficiently to move the amount of sediment introduced through the model and provide the width and depth required for navigation. Structures were also required to improve the alignment of most of the

bends without increasing resistance to flow and shoaling in the crossings.

24. Results of tests of this plan indicated the following general conclusions:

a. With the tailwater elevation furnished based on the effects of the lock and dam downstream and no change in the rate of sediment introduced from existing conditions, greater contraction of the channel than that indicated by the typical cross sections furnished by LMN would be required to obtain adequate widths and depths for navigation.

b. Realignment of the concave bank would be required in some of the bends to improve flow conditions and alignment of the channel through the bends.

c. Longitudinal dikes were the most effective structures in realigning the channel along the concave side of bends. These structures would have to be high enough to prevent flow over their tops. Flow over their tops would tend to reduce depths and cause tows to be moved toward and possibly over the structure.

d. Structures would be required along the convex side of some of the bends to increase the width of the navigation channel along the concave side.

Any substantial change in water-surface elevations as affected by locks and dams and other channel modifications would affect the rate of sediment movement and would have an appreciable effect on channel development and the number of structures required.

Plan B

Description

25. Plan B was based on the use of a realigned channel that would deviate from the existing channel in many locations by the use of cutoffs and modifications of the existing bank lines (Figure 3). The modifications would include excavations, revetments, and dike structures designed to provide bends with a minimum radius of 5000 ft and to prevent shoaling in the crossings and relatively straight reaches. The old bendways created by cutoffs or channel realignment were closed off with structures at the upper ends and kept open with structures at the lower ends for navigation, recreation, or enhancement of fish and wildlife.

26. The structures included in the initial plan are listed in Table 2 and shown in Plates 14 and 15. At the start of the test the channel was molded to typical cross sections furnished by LMN which provided a continuous 9-ft channel throughout the length of the model. The model was operated by reproducing the hydrograph shown in Plate 7 and by maintaining the tailwater elevations based on the rating curve furnished. There was no change in the rate of introducing bed material from that developed during the verification test which was based on existing conditions.

Results

27. Results of test of Plan B after three runs, shown in Plates 14 and 15, indicate that shoaling of the channel started in the upper reach and moved progressively downstream. A review of the results indicated that the channel had not stabilized after three reproductions of the hydrograph and continued shoaling could be expected in most of the reach, although an adequate channel was obtained downstream of about mile 76.6. With deposition occurring in the upper reach, the amount of sediment moving farther downstream would be less than the amount introduced at the upper end of the model. However, as the cross sections of the channel in the upper reach become adjusted to the flow and sediment conditions imposed, the amount of sediment moving downstream would be increased until the total sediment introduced is passed through the entire reach and would have a tendency to shoal from mile 76.6 downstream more than indicated. The lower entrance to the old bendway remained open but sediment deposited to above normal pool behind the longitudinal dike at mile 70.06, limiting the width of the old bendway channel at 9-ft navigation depth to 500 ft just upstream of the entrance.

28. In general, results of this test indicate that the typical cross sections submitted for use in molding the model bed were too large to be maintained with the flow hydrograph and sediment load used. Results also indicate that a problem might occur in upper bend (mile 77) where the curvature of the bend changes from a radius of 5000 ft to 6000 ft.

Plans B-1 Through B-15

29. Tests of Plans B-1 through B-15 were in the nature of preliminary tests during which progressive modifications were made in the dike structures designed to eliminate shoaling problems indicated in each preceding test. Since these tests did not produce a satisfactory channel, results are not included herein.

Plan B-16

Description

30. Plan B-16 included modifications developed during tests of Plans B-1 through B-15 and additional modifications based on the results of test of Plan B-15. The structures included in this plan are shown in Plates 16 and 17 and are listed in Table 2. It should be noted that with this plan, dikes would be required along the entire convex side (left descending bank) of the long bend in the upper reach. These dikes were spaced from 1000 to 2000 ft apart and contracted the channel to 300 ft at normal pool elevation. Modifications and/or additions of structures were also made that were designed to maintain access to the old bendways.

Results

31. Results shown in Plates 16 and 17 indicate a channel of at least 9 ft in depth throughout the reach. Channel widths with project depth in the upper bend upstream of mile 78 varied from about 130 to 190 ft. However, it should be considered that the model had a tendency to be some 3 to 5 ft shallower than the prototype, as indicated by the verification test. Considering this difference between model and prototype, depths and widths in the river could be expected to be somewhat greater in the upper reach than those indicated by results of the test of this plan. Raising the dike on the right bank just downstream of the lower entrance to the old bendway at mile 70.00 from el 41 to el 46 (Table 2) concentrated the flow that overtopped the dike at mile 70.06 in the bendway channel entrance. This resulted in widening the channel from 500 to 800 ft at 9-ft navigation depth.

Plans B-17 Through B-21

32. Tests of Plans B-17 through B-21 were in the nature of preliminary tests during which various modifications were tested in an effort to develop a plan that would reduce the structures required to develop an adequate channel. Since the results were used to develop the final plan, the data on these plans are not included herein.

Plan B-22

Description

33. Plan B-22 was essentially the same as Plan B-16 except that the dikes along the left bank in the bend upstream of mile 75 were replaced with a series of dikes about 2000 ft apart with the control limit line 350 ft from the right bank at normal pool elevation (Plate 18). Crests of the dikes upstream of mile 77 sloped from el 35 at the channel ends to el 50 in 62 ft, then to el 60 in 88 ft with the remainder of the dikes to top bank at el 60. Crests of the dikes between mile 75 and 77 sloped from el 35 at the channel end to el 60 in 150 ft with the remainder of the dikes to top bank at el 60.

Results

34. Results of tests of this plan, shown in Plates 18 and 19, indicate that the channel through the long upper bend was generally similar to that obtained with Plan B-16. A continuous channel of at least 9 ft in depth was indicated with minimum channel width of 200 ft except at several locations where the width was at least 180 ft. As indicated by the results of the model verification, depths in the prototype would tend to be 3 to 5 ft greater in the upper reach than those indicated by the model results with corresponding increase in project channel widths. The downstream entrance to Choctaw Bend remained open even after seven hydrographs.

Discussion of Results - Plan B

35. The Plan B alignment included a long bend of more than 180 deg consisting of a compound curve with radii of 5000 ft in the upper portion and 6000 ft in the lower reach. As in the case with the Plan A alignment, the controlled channel width initially was too large to maintain a navigation channel of adequate depth and width. Accordingly, the channel had to be contracted along the convex side to maintain an adequate navigation channel along the concave bank and to reduce the tendency for the channel to meander within the long bend. The downstream entrance of old bendway channels could be kept open with properly designed dikes in the entrance.

36. The upper reach required about 1 mile of dikes for each 3 miles of channel and less in the lower reach. The channel along the Plan B alignment would have to be developed by excavation through most of its length. The length of dikes required could be reduced considerably by decreasing the width of the excavated channel based on the elevation and length of the dikes used in the test of Plan B-22. Even with the plan as tested, the length of dikes required in the upper reach would be about one-third less than that required with the Plan A alignment. These results were based on the computed effects of the lock and dam downstream on water-surface elevations and with the same amount of sediment entering the reach with each flow reproduced as used without the effects of the lock and dam and other channel improvements. Disposal of the dredged material was not considered in these tests.

Plan C

Description

37. Plan C involved the development of a cutoff across Choctaw Bend. The purpose of tests of this plan was to determine the best method of developing cutoffs in this and other reaches of the river. Plan C, the initial plan tested, was furnished by LMN and included the following (Plate 20):

a. A pilot cut across the neck of the bend that was 200 ft wide in the upper reach and 90 ft wide in the lower 1240 ft with bottom at el 22 (18 ft below normal pool).

b. The left bank upstream and downstream of and in the entrance to the pilot cut was reshaped on a smooth alignment and revetted (R72.5L).

c. The right bank of the lower reach of the cutoff was revetted along the proposed ultimate alignment (R70.0R). It was assumed that this would be a trench-filled revetment.

d. Two dikes (D72.0R and D71.8R) were placed across the upper end of the existing bendway channel. A 380-ft section of each dike along the left side consisted of piles to permit some flow through the bendway until the cutoff developed.

e. Three dikes and a section of revetment (D70.0R, D69.9R, D69.8R, and R69.8R) were placed near the lower end of the existing bendway channel to prevent shoaling in the downstream entrance to the bendway after the cutoff developed. Dike D70.0R was 300 ft long extending from the lower end of the revetment at el 57 and sloping to el 44 in 100 ft and to el 41.5 in the next 200 ft. Dike D69.9R sloped from el 46 at the bank to el 41 and dike D69.8R sloped from el 42 at the bank to el 40 at the channel end.

f. A combination of revetment and pile dike (R69.7L and D69.7L) was placed on the proposed left bank line opposite the lower end of the existing bendway.

38. The test was started with the bendway channel molded to the conditions indicated by the 1968 prototype survey (Plate 2), and the channel upstream and downstream was the same as that obtained at the end of test of Plan B-22 (Plate 19). The model for this test was operated by reproducing the hydrograph shown in Plate 21 which was the same as that used for the test of Plan B except that stages were based on open river conditions (without the effects of a lock and dam downstream). A plug was left in the upper end of the pilot cut and an opening 30 ft wide was made in the plug at the start of the test.

Results

39. The plug in the upper end of the pilot cut started to erode immediately after start of the test with the 24,000-cfs flow. The upper end of pilot cut widened to 450 ft and most of the riverflow was passing through the cutoff with very little sediment moving into the old bendway.

There was little change in the development of the cutoff until the high flows (about 85,000 cfs) that occurred about halfway through the hydrograph. Bank caving and erosion of the pilot cut continued during the high flows but decreased rapidly during the lower flows after the high-water period. The configuration of the channel after one reproduction of the hydrograph is shown in Plate 22. Though channel development was not complete, these results indicate that the width of the pilot cut had increased, varying from about 300 to 450 ft, but depths had decreased. The deeper channel through the cutoff tended to meander and generally develop away from the revetted right bank at the lower reach of the cutoff. There was very little tendency for bed material to move into the upper end of the old bendway, but some narrowing occurred in the lower end. However, a channel of adequate width and depth was maintained in the lower entrance.

Plan C-1

Description

40. Conditions for the test of Plan C-1 were the same as those obtained at the end of test of Plan C except that the pile portion of closure dikes D72.0R and D71.8R were stone-filled to top bank elevation. With the stone fill, all flow into the upper end of the old bendway was eliminated.

Results

41. Results shown in Plate 23 indicate that with the complete closure of the old bendway, channel development accelerated. The channel followed the left bank of the cutoff farther downstream but still crossed toward the right along the lower portion of the revetted bank. The cutoff channel was generally deeper and wider than that obtained with Plan C, but still did not provide a continuous 9-ft navigation channel. The downstream entrance to the old bendway channel remained open with no change from Plan C indicated.

Plan C-2

Description

42. Plan C-2 was started with the same dike plan as Plan C (Plate 20) except that dike D72.0R across the upper end of the old bendway and the dikes at the lower end (D69.9R, D69.8R, and D70.0R) were eliminated. Conditions upstream and downstream of the proposed cutoff and in the old bendway channel were the same as those obtained at the end of test of Plan C-1. The pilot channel was remolded to the Plan C beginning conditions.

Results

43. Results shown in Plate 24 indicate that some deposition had occurred along the right side of the main channel extending across the upstream entrance to the old bendway channel. Most of the material forming the plug in the pilot cut had been removed, leaving a channel of at least 9 ft in depth through the cutoff. The 9-ft channel was narrow and remained generally along the alignment of the pilot cut. The crossing toward the right bank was a little farther downstream than with Plan C. This appeared to be caused by the shoaling along the right side extending past the entrance to the old bendway. The deeper channel did not meander back toward the left bank as in Plan C. Shoaling at the upstream entrance to the old bendway channel amounted to about 10 ft without the dikes.

Plan C-3

Description

44. Plan C-3 was the same as Plan C-2 except that closure dike D71.8R was removed and dike D72.0R at the upper end of the bendway channel was added. The model was remolded to conditions existing at the start of test of Plan C.

Results

45. Results of test of this plan, when compared with results of Plan C-2, indicate some reduction in the shoaling across the upstream

entrance to the old bendway channel and changes in the alignment of the channel through the cutoff (Plates 24 and 25). The channel past the upstream entrance to the old bendway was narrow and shifted from the left to right bank near the upper end of the cutoff. The channel remained mostly along the right bank and followed the revetted bank downstream. The downstream entrance channel to the old bendway was narrower than with Plan C-2.

Plan C-4

Description

46. The Plan C-4 dike plan was the same as Plan C except that none of the structures in the old bendway channel were included. Conditions upstream and downstream of the cutoff and in the old bendway channel were the same as those obtained at the end of test of Plan C-3. The pilot cut was remolded to Plan C beginning conditions.

Results

47. Results shown in Plate 26 indicate little difference in the developments within the cutoff compared with the results of test of Plan C. The channel crossed from the left bank to the right bank of the cutoff a short distance downstream of the upper end and then crossed back toward the left bank away from the right bank revetment in the lower reach. There was more deposition throughout the old bendway channel than that obtained with Plan C.

Discussion of Test of Plan C

48. Tests of Plan C were conducted to determine the effects of various plans designed to develop a cutoff of a relatively long bend. In the evaluation of the results of these tests, it should be considered that in the model the cutoff was made through easily erodible material and each plan was subjected to only one reproduction of the typical annual hydrograph. Results of tests of Plan C indicated the following:

<u>a</u>. The size of the pilot cut was sufficient to pass most of

the flows up to about 85,000 cfs without any appreciable development within the cutoff, particularly with the large opening in the dikes across the old bendway channel.

b. There was little difference in the rate of development of the cutoff with and without the partial closure of the old bendway channel as tested in Plans C, C-2, C-3, and C-4. The rate of development of the cutoff was increased with complete closure of the old bendway as in Plan C-1.

c. Use of one or two closure dikes with partial openings, whether located near the upstream entrance to or farther downstream in the bendway, had little effect on the rate of development of the cutoff. However, greater deposition occurred near the entrance to the old bendway channel with the closure farther downstream.

d. The deeper channel tended to meander within the cutoff with most of the plans tested. However, it should be considered that the cutoff was not fully developed with any of the plans tested.

e. With no structures in the old bendway channel (Plan C-4) there was a tendency for deposition throughout that channel.

PART IV: SUMMARY OF RESULTS AND CONCLUSIONS

Model Limitations

49. The limitations of the model based on the model verification, the hydrograph used, and the tailwater elevations furnished based on existing conditions and conditions expected from the construction of a lock and dam and channel modifications downstream should be considered in an analysis and evaluation of the results of this investigation. It should also be considered that the study was based on a reach of the Red River selected to provide some general information that would be applicable to the design of other reaches rather than for the development of plans for that reach. Because of the nature of the reach and facilities used that did not permit the reproduction of overbank flow, the model tended to be from 3 to 5 ft shallower in the upper reach than was indicated by the prototype survey and this has to be considered in the evaluation of test results.

50. Tests of improvement Plans A and B were conducted by reproducing the effects of the lock and dam and channel modifications downstream of the reach based on data furnished. Any changes in these effects from those used in the tests could affect channel development. Also, the rate of introducing bed material at the upper end of the model was not changed based on the assumption that changes upstream and downstream would not affect the rate of sediment moving into the reach under study. Since most sediment moves during high flows when dam gates are open and flow is open river, this is believed to be a reasonable assumption.

51. Tests of Plan C were conducted with the channel upstream and downstream of the proposed cutoff the same as that obtained at the end of test of Plan B. However, since tailwater elevations for Plan C were based on conditions before the construction of the lock and dam, some degradation of the channel bed could be expected during the lower flows. Also, the bed and banks through which the pilot cut was made consisted of easily erodible material (same as the channel bed). This would make

the rate of development of the cutoff tend to be much faster than could be expected under most prototype conditions. Also, results of tests of Plan C were based on the conditions obtained after only one reproduction of the annual hydrograph.

Results and Conclusions

52. The following general results and conclusions were indicated by the model investigation:

a. The alignment of the channel for Plan A included many rather sharp and irregular bends, some long straight reaches, and some short crossings. Development of a satisfactory channel with this alignment would involve the use of a considerable amount of construction in the form of training structures of various types and revetment.

b. With Plan A, alignment structures would be required to contract the channel sufficiently to move the sediment entering the reach from upstream and to provide the additional depth and width of channel required for navigation. Structures would also be required to improve the alignment of most bends and provide adequate depths over crossings during low flows.

c. The alignment of Plan B consisted of one long bend of more than 180 deg and a large number of short flat bends and short crossings. Because of the alignment and cutoffs involved, the length of channel of Plan B was considerably shorter than that of Plan A.

d. Structures would be required with the Plan B alignment to contract the channel, particularly in the long bend, to provide adequate navigation channel width and depth, reduce the tendency for the channel to meander within the bend, force the channel to cross between the short flat bends, and close off some of the side channels through the old bendways.

e. The length of dikes required per mile of channel with the alignment of Plan A would be about 50 percent more than with the Plan B alignment. Considering the shorter length of channel with Plan B and the greater number of dikes on the deeper concave side of the channel with Plan A, the amount of dike construction required would be considerably less with the Plan B alignment. Development of the channel with the Plan B alignment will require considerable excavation. The length of dikes

required with Plan B could be further reduced by reducing the width of the excavated channel, particularly in the long bend.

f. The reach downstream of the long bend with the Plan B alignment was generally too straight with relatively short flat bends and short crossings to provide a satisfactory channel without the use of training structures.

g. The rate of development of a cutoff as tested with Plan C would depend on flow conditions and the amount of flow passing through the old bendway. Other factors that could affect the rate of development would be the erodibility of the material through which the cutoff is made and the relative length of the cutoff channel with respect to the bendway channel.

h. The openings in the dikes with the 380-ft permeable pile section were too large to have any appreciable effect on the cutoff during the early stages of development. With the single closure dike at the upper end of the old bendway channel, there was a deeper connection between the main channel and the bendway than with the closure dike farther downstream in the bendway.

i. The deeper channel within the cutoff tended to meander and be somewhat unstable during the early stages of development. Based on the results of tests of Plan B, structures would probably be required to maintain the channel along the revetted bank in the lower reach of the cutoff.

j. Shoaling will occur in the bendway channel starting at its upper end when there is substantial flow through the bendway channel. Maintaining the old bendway for fish, wildlife, and recreation or port facilities would require that the upper end of the old bendway be closed as soon as conditions permit. Shoaling will also occur in the lower end of the bendway. Maintenance of an entrance at the lower end of the old bendway without dredging would require structures designed to block the movement of sediment-carrying bottom currents from entering the channel.

k. In general, results of this investigation indicated that the typical cross sections furnished and natural channel widths in some reaches were too large to provide adequate channel depths and widths for navigation without changes in flow conditions and rate of sediment movement. Also, development of a satisfactory channel would require the closure of old bendways that are bypassed or any secondary channels that would divert some of the flow from the main channel.

Table 1

Dike Location and Elevation

Plan A

River Mile	Dike Type*	Original Length, ft**	Elevation for Plan, ft msl† A	A-12	A-13
		Dikes on Right Bank			
79.25	L-Head	200	48-46	60-60	60-60
		150	46-36	60-60	60-60
79.17	L-Head	150	48-46	60-60	60-60
		150	46-36	60-60	60-60
79.11	Spur	165	48-46	60-60	60-60
79.06	L-Head	175	48-46	60-60	60-60
		250	46-36	60-60	60-60
79.00	L-Head	200	48-46	60-60	60-60
		200	46-36	60-60	60-60
78.95	L-Head	165	48-46	60-60	60-60
		250	46-36	60-60	60-60
78.90	L-Head	145	48-46	60-60	60-60
		225	46-36	60-60	60-60
78.78	Spur	200	--	60-60	60-60
78.70	Long.	400	46-44	--	--
78.69	Spur	220	--	55-55	55-55
78.61	Spur	290	--	55-55	55-55
78.48	Spur	350	--	50-50	50-50
78.15	Long.	1000	46-36	60-60	60-60
78.10	Baffle	200	--	60-60	60-60
78.04	Baffle	200	--	60-60	60-60
78.00	L-Head	200	47-45	60-60	60-60
		225	45-45	60-60	60-60
		250	45-35	60-60	60-60
77.87	L-Head	250	47-45	60-60	60-60
		250	47-35	60-60	60-60
77.79	L-Head	160	47-35	60-60	60-60
		200	45-35	60-60	60-60
77.44	Long.	250	45-43	60-60	60-60
	Baffle	200	--	60-60	60-60
77.35	Spur	430	--	60-60	60-60

(Continued)

Note: Brackets indicate one continuous dike.
* Long. indicates longitudinal dike.
** Original length in prototype feet.
† Elevation in feet mean sea level - bank or upstream elevation then channel or downstream elevation.

(Sheet 1 of 4)

Table 1 (Continued)

River Mile	Dike Type	Original Length, ft	Elevation for Plan, ft msl A	A-12	A-13
			Dikes on Right Bank (Continued)		
77.28	Spur	300	47-45	--	--
77.10	Spur	300	--	50-50	50-50
76.90	Long.	600	45-35	50-50	50-50
	Baffle	250	--	50-50	50-50
76.78	L-Head	250	47-45	50-50	50-50
		350	45-35	50-50	50-50
76.69	L-Head	300	47-45	50-50	50-50
		300	45-35	50-50	50-50
76.60	L-Head	320	47-45	50-50	50-50
		375	45-35	50-50	50-50
76.50	L-Head	200	47-45	50-50	50-50
		300	45-35	50-50	50-50
75.98	Long.	325	--	50-50	50-50
75.80	Spur	300	47-45	50-50	50-50
75.78	Spur	350	--	50-50	50-50
75.64	Spur	300	--	45-45	45-45
75.52	Spur	270	--	--	50-50
74.98	Long.	750	45-35	45-45	45-45
	Baffle	150	47-45	47-45	47-45
74.82	L-Head	200	47-45	47-45	47-45
		250	45-35	45-45	45-45
74.76	Spur	225	47-45	47-45	47-45
74.76	Spur	260	47-45	47-45	47-45
	Wing	240	--	45-45	45-45
74.65	L-Head	260	--	45-45	45-45
		250	--	47-45	47-45
74.25	Long.	400	45-43	47-47	47-47
	Baffle	180	--	47-47	47-47
74.23	Spur	400	--	44-44	44-44
74.18	Spur	300	47-45	--	--
74.14	Spur	450	--	40-40	40-40
72.70	Long.	600	45-43	45-43	45-43
	Baffle	325	47-45	47-45	47-45
72.50	Spur	270	47-45	47-45	47-45
72.42	Spur	260	47-45	47-45	47-45
71.40	Long.	800	45-43	45-35	47-45
	Baffle	280	47-45	47-45	47-45
71.25	Long.	430	47-47	47-47	47-47
	Baffle	175	47-45	47-45	47-45
71.15	Long.	350	44-34	44-34	45-44
	Baffle	200	46-44	46-44	46-44

(Continued)

Table 1 (Continued)

River Mile	Dike Type	Original Length, ft	Elevation for Plan, ft msl A	A-12	-13
			Dikes on Right Bank (Continued)		
71.00	L-Head	450	44-34	44-34	44-34
		150	--	46-44	46-44
70.20	Long.	750	44-34	44-44	44-44
	Baffle	500	46-44	46-44	46-44
70.14	Spur	160	--	44-44	44-44
70.00	Spur	220	46-44	--	--
69.99	Spur	300	--	44-44	44-44
69.91	Spur	400	--	44-44	44-44
69.35	Long.	1700	44-34	44-34	44-34
	Baffle	350	46-44	46-44	46-44
			Dikes on Left Bank		
79.60	Long.	450	46-44	60-60	60-60
	Baffle	200	46-44	60-60	60-60
79.43	Spur	360	--	57-57	57-57
79.37	Spur	220	48-46	--	--
79.33	Spur	420	--	57-57	57-57
79.20	Spur	460	--	57-57	57-57
79.07	Spur	400	--	57-57	57-57
	Wing	350	--	57-57	57-57
78.87	Spur	400	--	57-57	57-57
78.50	Long.	1100	46-44	60-60	60-60
78.46	Baffle	200	--	60-60	60-60
78.35	Baffle	480	48-46	60-60	60-60
78.25	Spur	520	--	60-60	60-60
78.21	Spur	350	48-46	--	--
78.11	Spur	360	--	55-55	55-55
77.96	Spur	430	--	55-55	55-55
77.28	Spur	400	--	50-50	50-50
77.65	Spur	580	--	50-50	50-50
77.54	Spur	550	--	50-50	50-50
77.07	Long.	350	45-43	50-50	50-50
	Baffle	150	--	50-50	50-50
76.93	Spur	270	--	50-50	50-50
76.86	Spur	200	45-45	--	--
76.83	Spur	310	--	50-50	50-50
76.65	Spur	300	--	50-50	50-50
76.45	Spur	400	--	50-50	50-50
76.25	Spur	600	--	50-50	50-50

(Continued)

Table 1 (Concluded)

River Mile	Dike Type	Original Length, ft	Elevation for Plan, ft msl A	A-12	A-13
			Dikes on Left Bank (Continued)		
76.08	Spur	425	--	50-50	50-50
75.55	Long.	900	45-43	45-45	45-45
75.52	Baffle	200	--	47-45	47-45
75.40	Baffle	280	47-45	47-45	47-45
75.35	Spur	350	--	45-45	45-45
75.31	Spur	300	47-45	--	--
75.26	Spur	430	--	45-45	45-45
75.16	Spur	560	--	45-45	45-45
75.00	Spur	450	--	45-45	45-45
74.10	Long.	1200	45-35	45-35	45-35
	Baffle	175	--	47-45	47-45
73.60	Long.	400	45-35	45-43	45-43
	Baffle	150	--	45-45	45-45
73.57	Spur	190	--	42-42	42-42
73.48	Spur	150	45-45	39-39	39-39
73.30	Spur	300	--	39-39	39-39
72.00	Long.	3200	45-35	50-50	50-50
72.22	Baffle	200	--	50-50	50-50
72.08	Baffle	490	--	50-50	50-50
71.98	Baffle	750	47-45	50-50	50-50
71.85	Baffle	425	--	50-50	50-50
71.50	Long.	450	45-43	--	--
71.46	Long.	250	--	45-45	45-45
71.44	Spur	120	--	45-45	45-45
71.37	Spur	200	--	43-43	43-43
71.32	Spur	200	45-45	--	--
71.30	Spur	300	--	40-40	40-40
70.93	Spur	340	--	40-40	40-40
70.75	Spur	390	--	40-40	40-40
70.05	Spur	280	--	50-50	50-50
69.80	Long.	1600	44-34	50-50	50-50
69.98	Baffle	350	--	50-50	50-50
69.88	Baffle	250	46-44	50-50	50-50
69.40	Long.	450	44-42	47-45	47-45
69.22	Spur	350	44-44	44-44	44-44
69.07	Spur	270	--	42-42	42-42

(Sheet 4 of 4)

Table 2

Dike Location and Elevation

Plan B

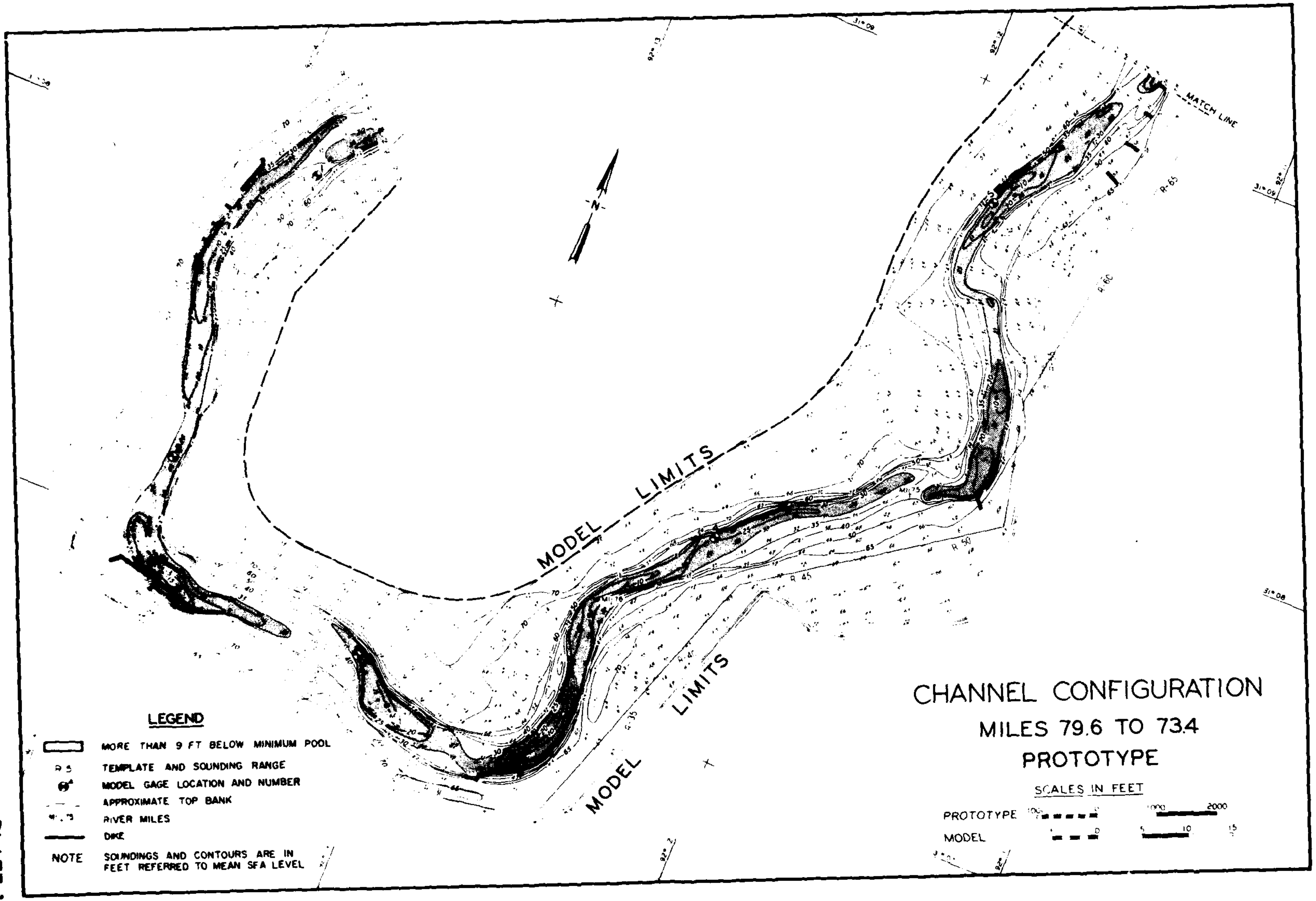
River Mile	Dike Type*	Original Length, ft**	Elevation for Plan, ft msl† B	B-16	B-22
		Dikes on Right Bank			
78.38	Long.	1300	68-68	68-68	68-68
78.09	Closure	1000	68-68	68-68	68-68
77.48	Long.	700	68-68	50-50	50-50
77.39	Spur	240	68-68	--	--
77.16	Long.	850	68-68	68-68	68-68
76.86	Closure	1200	68-68	68-68	68-68
76.20	Long.	375	68-68	43-43	43-43
75.33	Long.	1620	68-68	68-68	68-68
75.00	Closure	1000	68-68	68-68	68-68
74.78	Long.	1000	48-48	48-48	48-48
74.24	Spur	150	42-42	42-42	42-42
74.16	Spur	140	42-42	42-42	42-42
74.26	Spur	850	--	61-61	61-61
74.26	L-Head	240	--	61-61	61-61
73.51	Long.	1450	68-68	68-68	68-68
73.01	Long.	1150	42-42	42-42	42-42
72.92	Baffle	125	42-42	42-42	42-42
72.83	Baffle	170	42-42	42-42	42-42
72.81	Long.	450	--	42-42	42-42
72.75	Baffle	175	42-42	42-42	42-42
72.67	Spur	330	42-42	42-42	42-42
72.67	L-Head	245	--	42-42	42-42
72.13	Spur	330	66-66	66-66	66-66
72.13	L-Head	1475	66-66	66-66	66-66
71.77	Closure	650	68-68	68-68	68-68
70.06	Long.	800	41-41	41-41	41-41
70.00	Spur	300	41-41	46-46	46-46
70.00	L-Head	325	41-41	46-46	46-46
69.87	Spur	200	41-41	43-43	43-43
69.87	L-Head	150	41-41	43-43	43-43
69.26	Spur	360	68-68	68-68	68-68
69.26	L-Head	1600	68-68	68-68	68-68

(Continued)

Note: Brackets indicate one continuous dike.
* Long. indicates longitudinal dike.
** Original length in prototype feet.
† Elevation in feet mean sea level - bank or upstream elevation then channel or downstream elevation.

Table 2 (Concluded)

River Mile	Dike Type	Original Length, ft	Elevation for Plan, ft msl B	B-16	B-22
		Dikes on Left Bank			
79.48	Spur	200	--	--	60-35
79.25	Spur	500	--	40-50	--
79.08	Spur	200	--	--	60-35
78.87	Spur	420	--	40-50	--
78.67	Spur	190	--	--	60-35
78.52	Spur	400	--	40-50	--
78.41	Spur	380	--	40-50	--
78.39	Spur	190	--	--	60-35
78.03	Spur	350	--	40-50	--
77.60	Spur	190	--	--	60-35
77.42	Spur	450	--	40-50	--
77.28	Spur	420	--	40-50	--
77.26	Spur	200	--	--	60-35
77.15	Spur	450	--	40-50	--
77.07	Spur	370	--	40-50	--
77.06	Spur	185	--	--	60-35
76.56	Spur	270	--	40-50	--
76.15	Spur	360	--	38-48	--
76.08	Spur	180	--	--	60-46
75.91	Spur	375	--	37-47	--
75.78	Spur	120	--	--	60-46
75.72	Spur	385	--	37-47	--
75.41	Spur	120	--	--	60-46
75.38	Spur	400	--	36-46	--
75.19	Spur	375	--	34-44	--
75.19	Wing	300	--	34-44	--
75.15	Spur	130	--	--	60-46
73.72	Long.	900	42-42	42-42	42-42
73.60	Tie	150	42-42	42-42	--
73.53	Spur	200	42-42	42-42	42-42
73.40	Spur	190	42-42	42-42	42-42
71.78	Long.	1000	41-41	41-41	41-41
71.75	Spur	185	41-41	41-41	41-41
71.72	Spur	185	41-41	41-41	41-41
71.72	L-Head	250	--	41-41	41-41
71.68	Spur	450	--	38-38	38-38
69.32	Long.	1000	40-40	40-40	40-40
69.16	Baffle	200	40-40	40-40	40-40
69.07	Spur	400	40-40	40-40	40-40
68.97	Spur	520	40-40	40-40	40-40



CHANNEL CONFIGURATION
MILES 79.6 TO 73.4
PROTOTYPE

PLATE 1

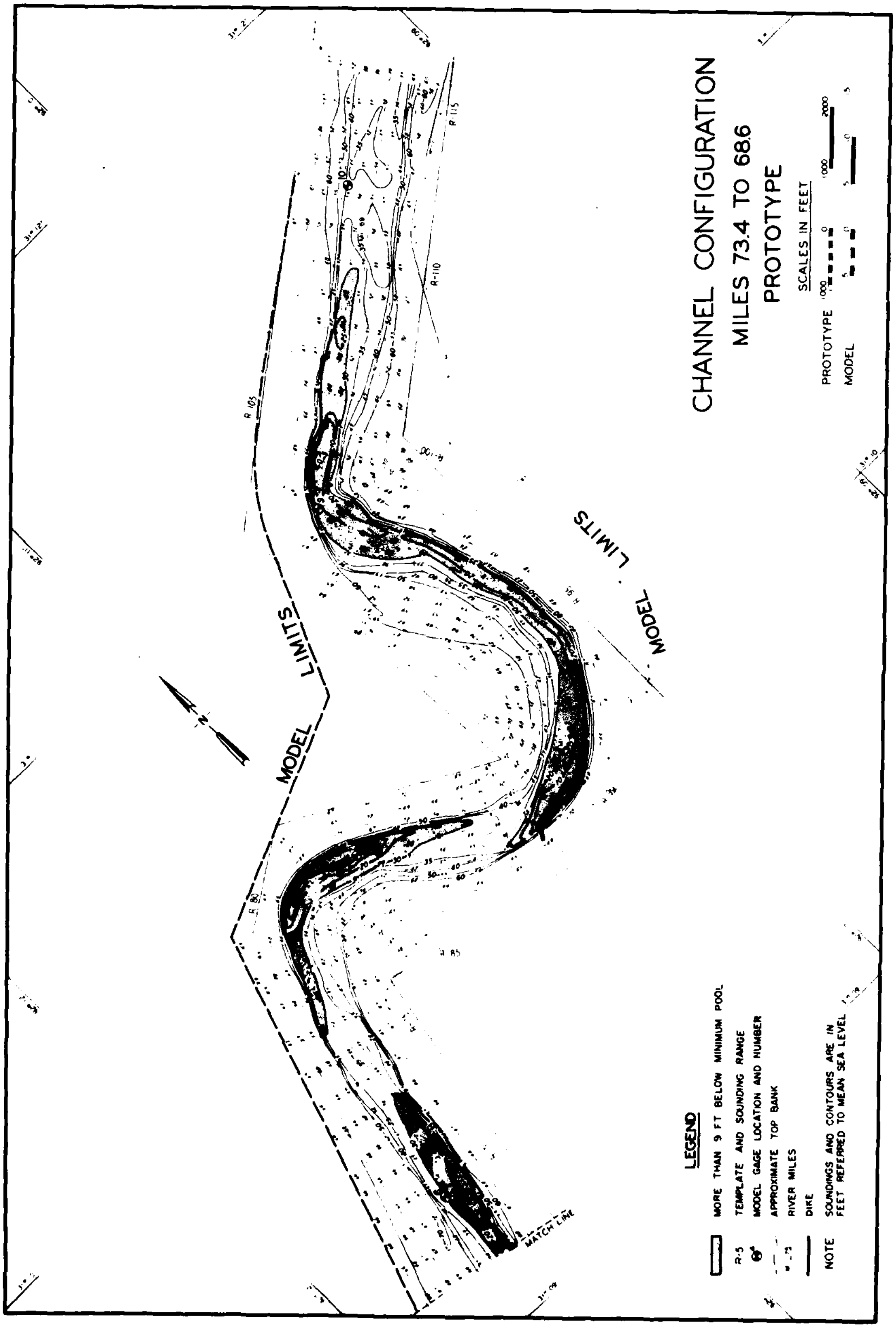
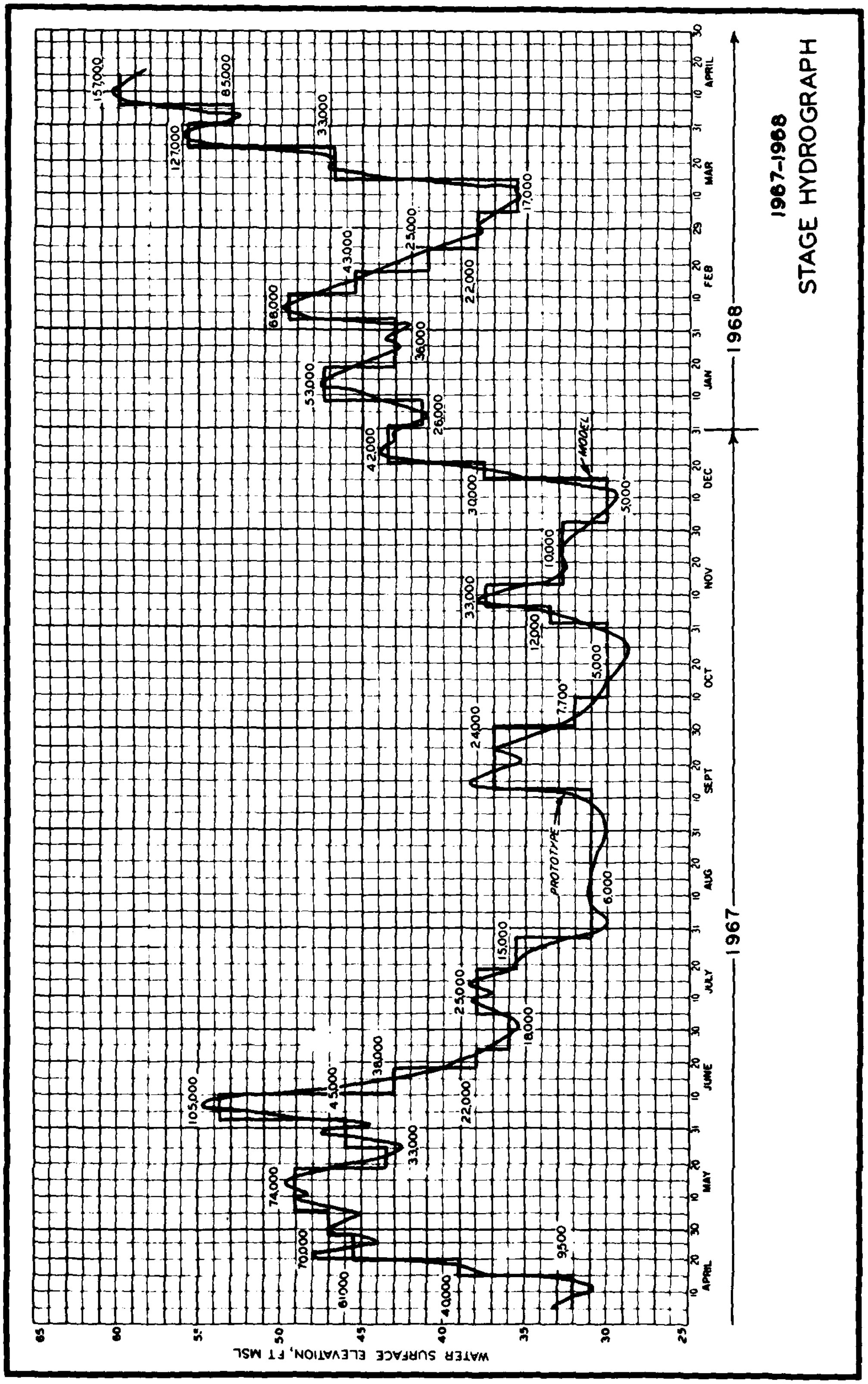

CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
PROTOTYPE
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MODEL LIMITS
MODEL LIMITS
MATCH LINE
R-80
R-85
R-100
R-105
R-110
R-115

PLATE 2



1967-1968
STAGE HYDROGRAPH

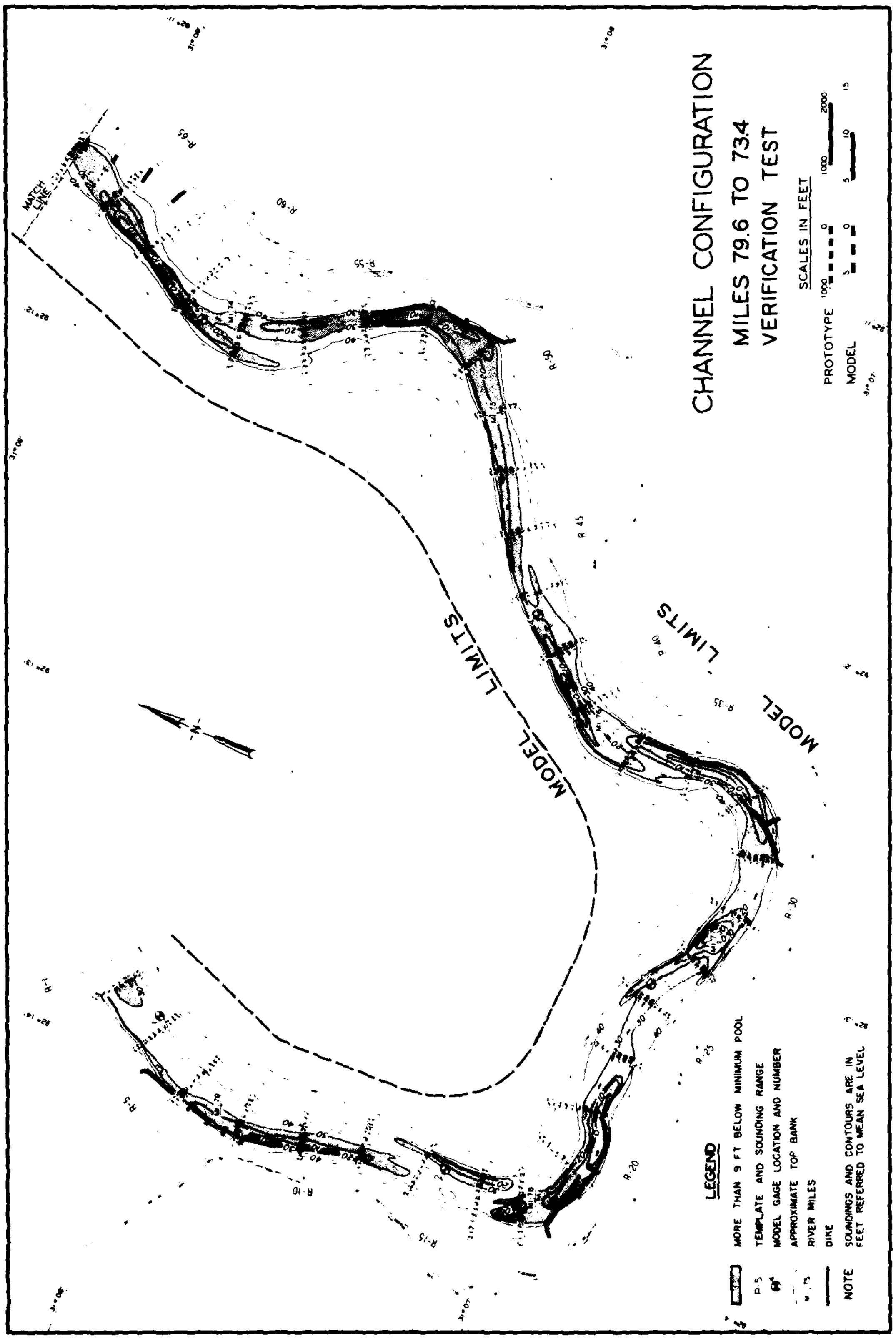

CHANNEL CONFIGURATION
MILES 79.6 TO 73.4
VERIFICATION TEST
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MODEL LIMITS
MODEL LIMITS
MATCH LINE
N
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55
R-60
R-65

PLATE 4

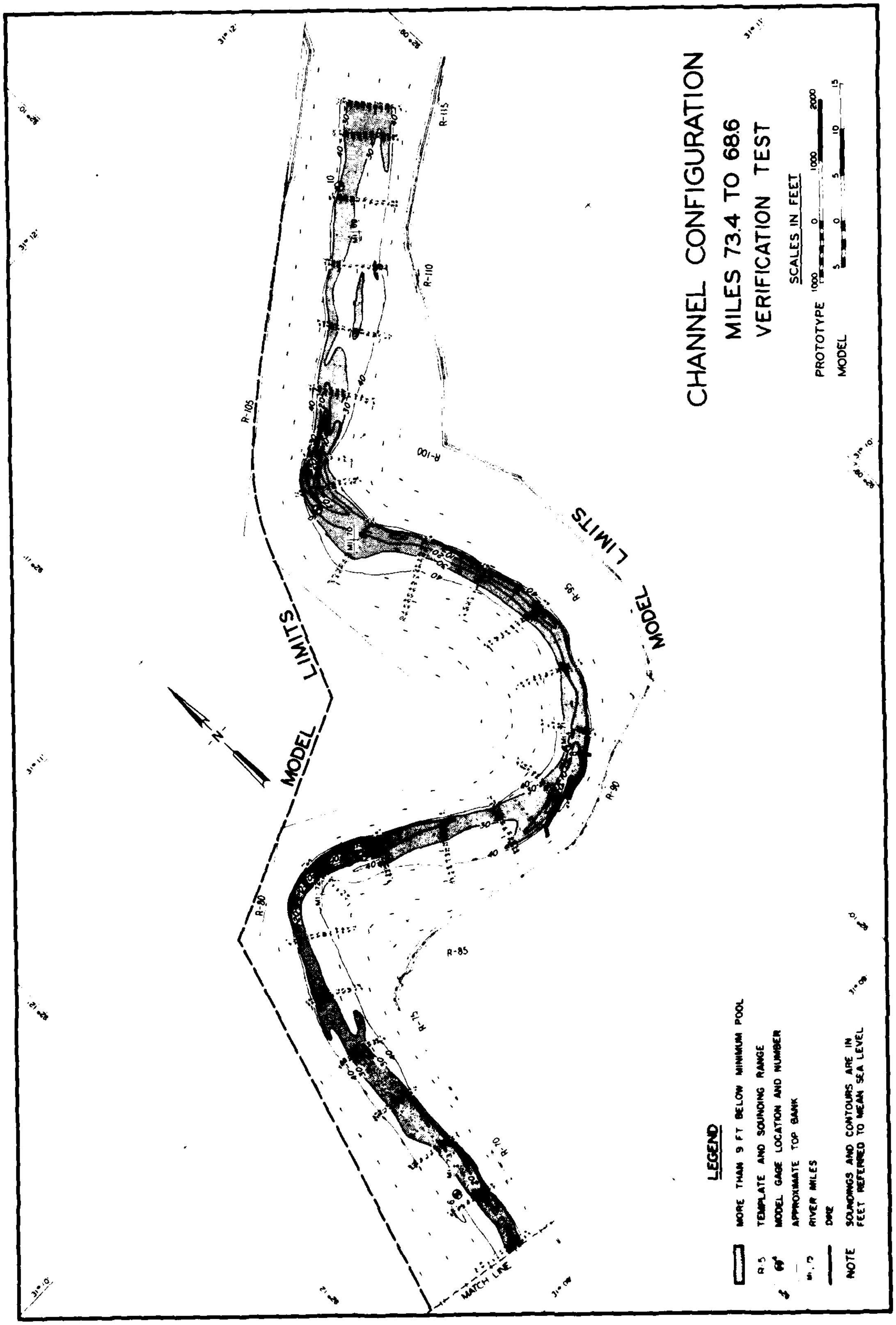
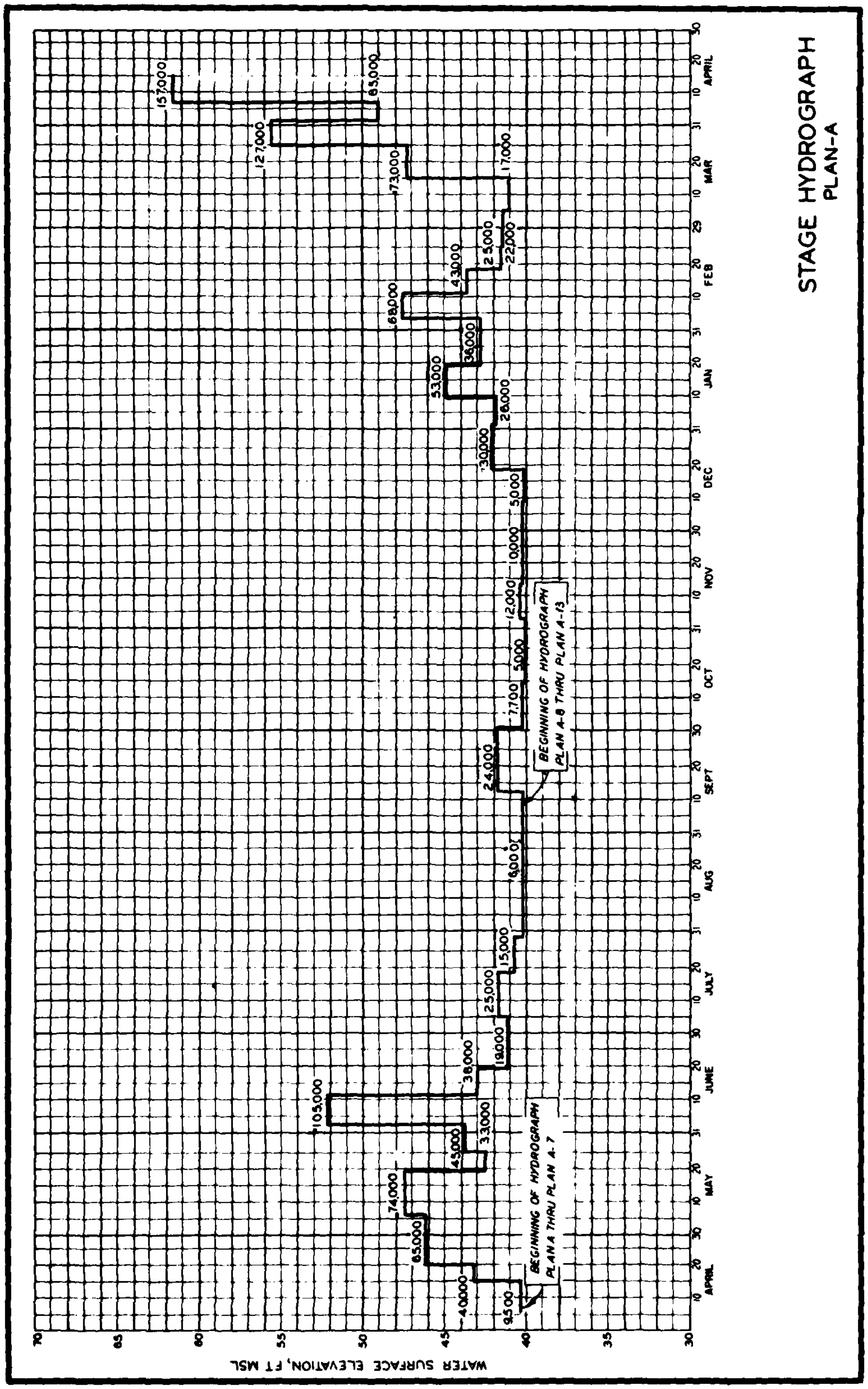
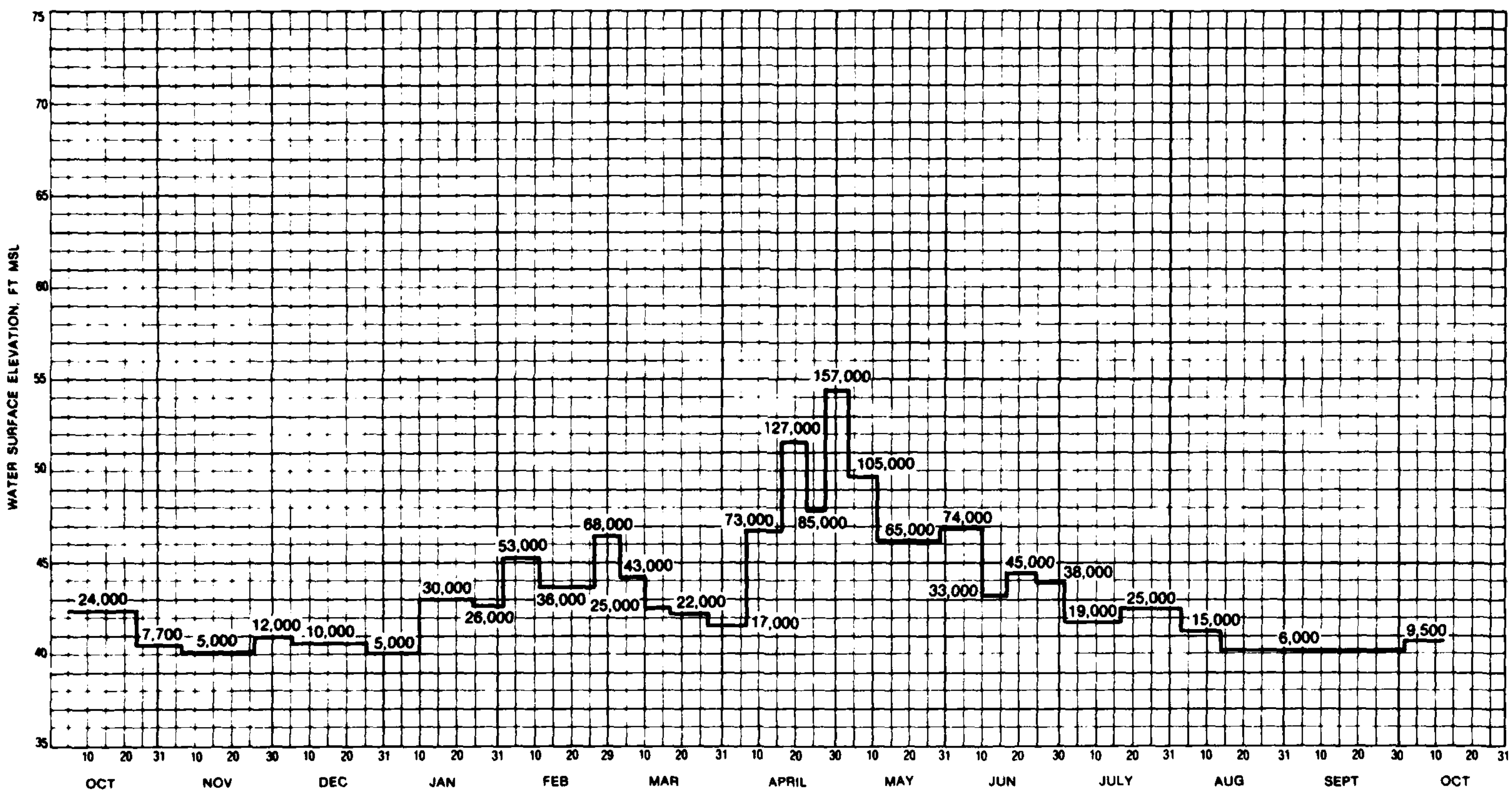

CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
VERIFICATION TEST
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
MODEL LIMITS
MODEL LIMITS
N
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
R-75
R-80
R-85
R-90
R-95
R-100
R-105
R-110
R-115

PLATE 5



STAGE HYDROGRAPH
PLAN-A

PLATE 6



STAGE HYDROGRAPH
PLAN-B

PLATE 7

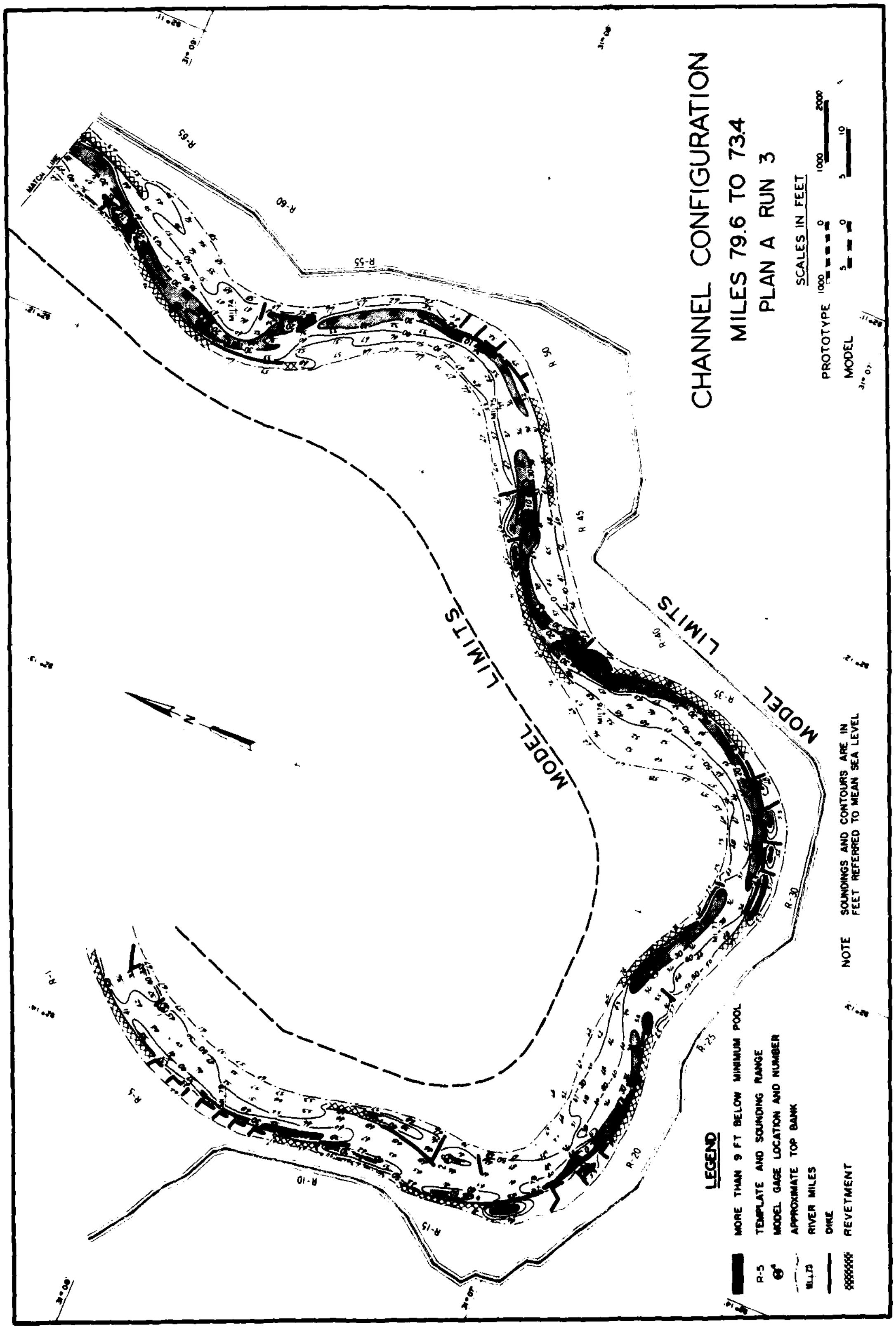

CHANNEL CONFIGURATION
MILES 79.6 TO 73.4
PLAN A RUN 3
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MODEL LIMITS
MODEL LIMITS
MATCH LINE
R-1
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55
R-60
R-65
N

PLATE 8

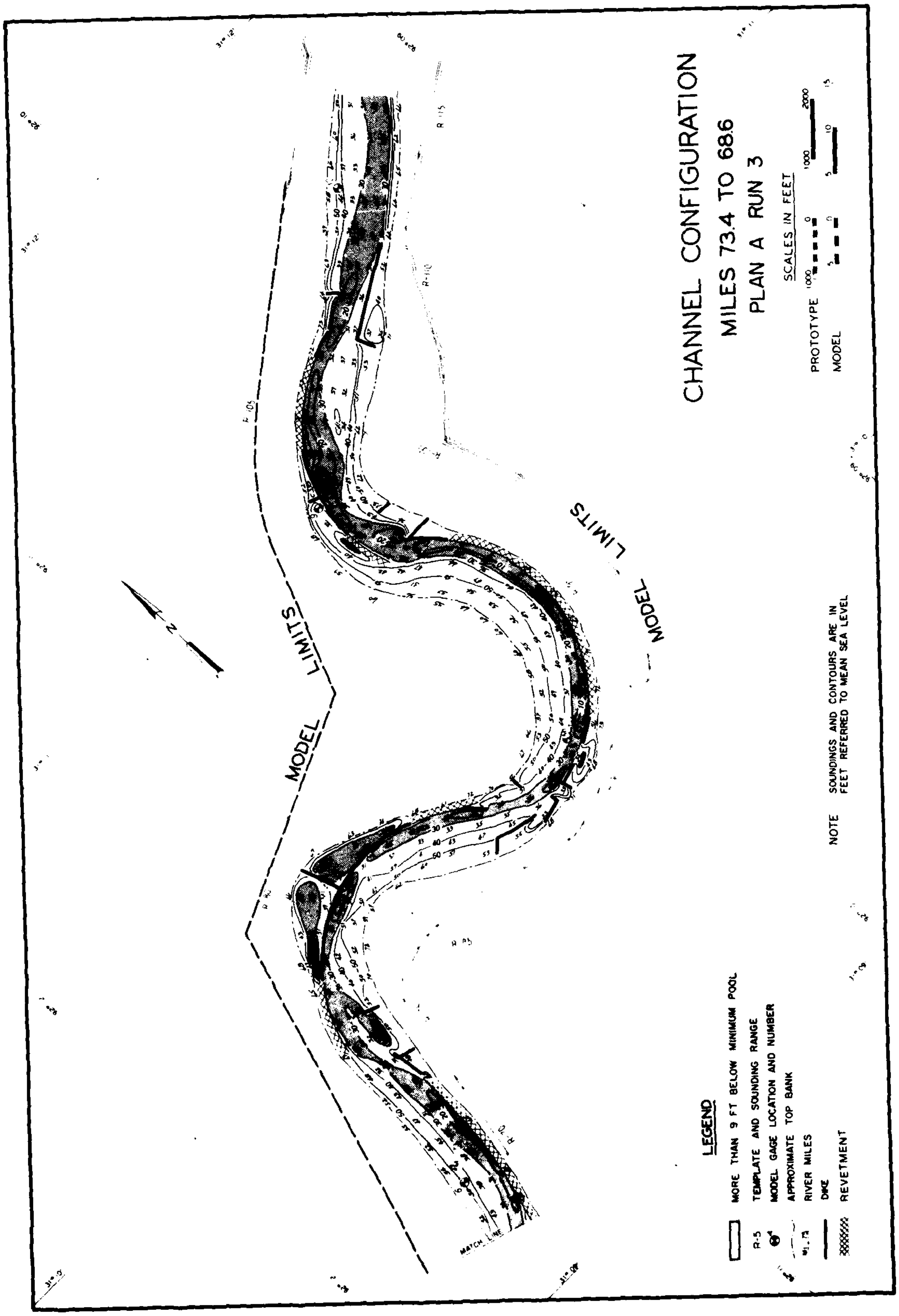

CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
PLAN A RUN 3
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
MODEL LIMITS
MODEL LIMITS
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
REVETMENT
MATCH LINE

PLATE 9

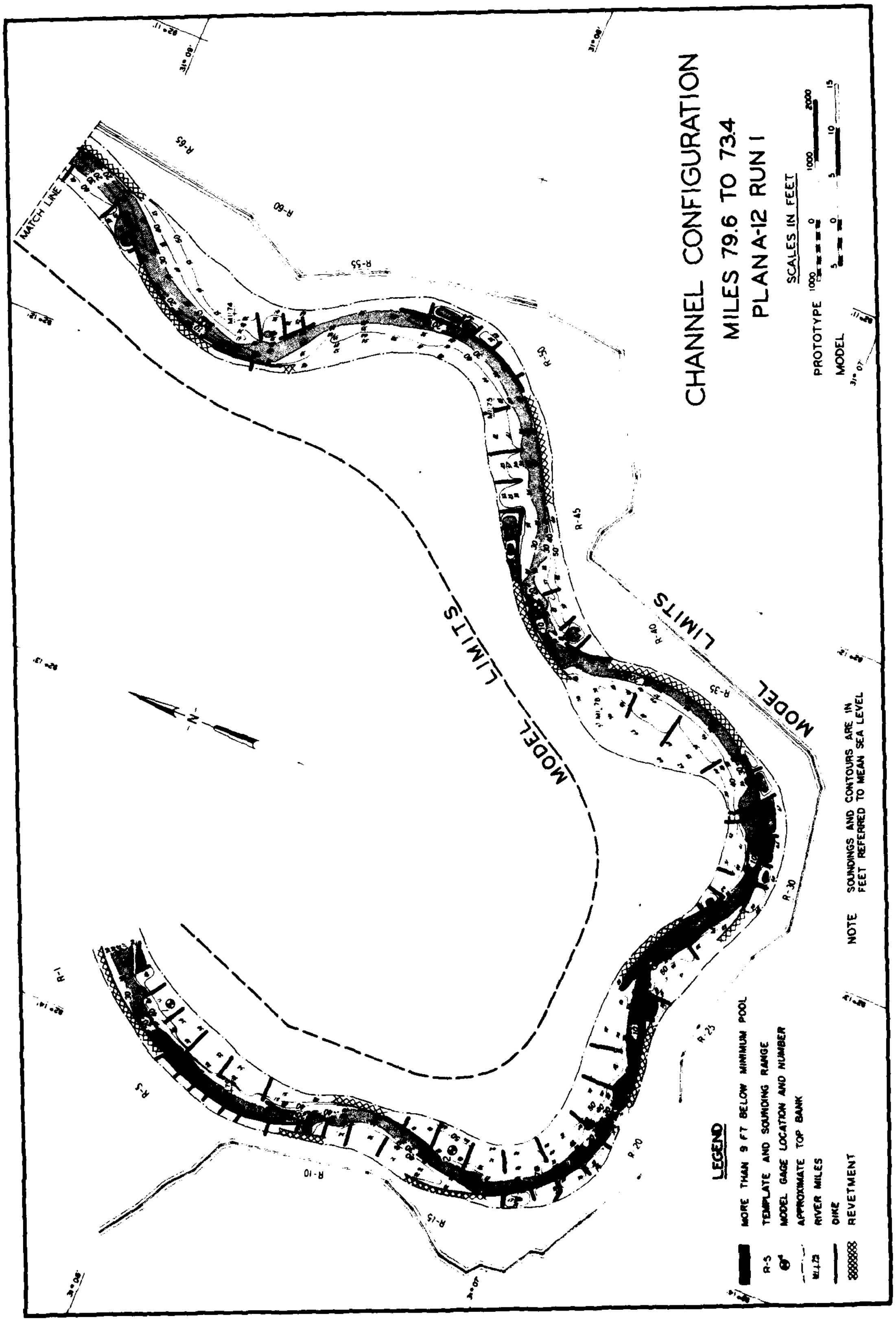

CHANNEL CONFIGURATION
MILES 79.6 TO 73.4
PLAN A-12 RUN 1
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
MODEL LIMITS
MODEL LIMITS
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
R-1
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55
R-60
R-65

PLATE 10

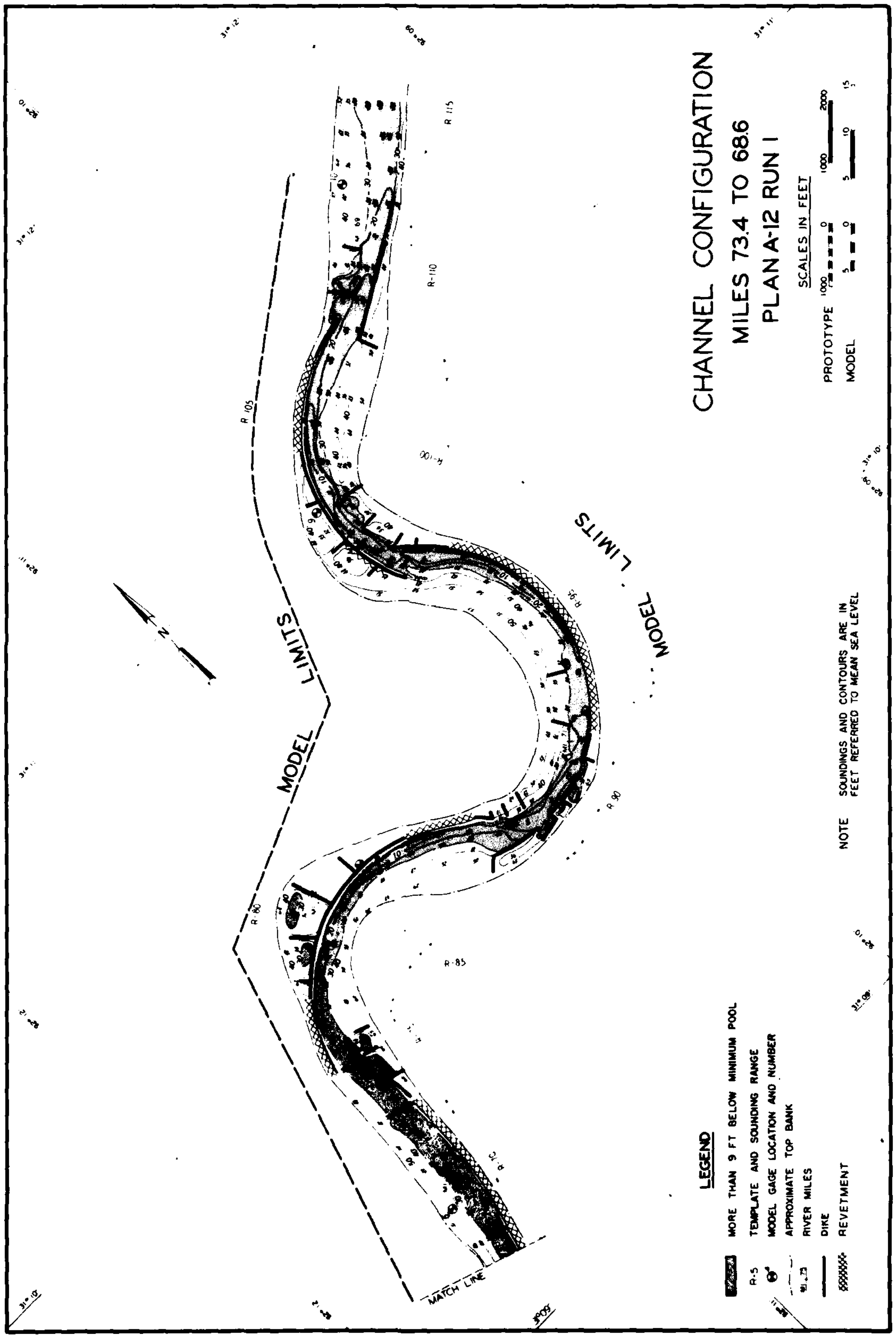
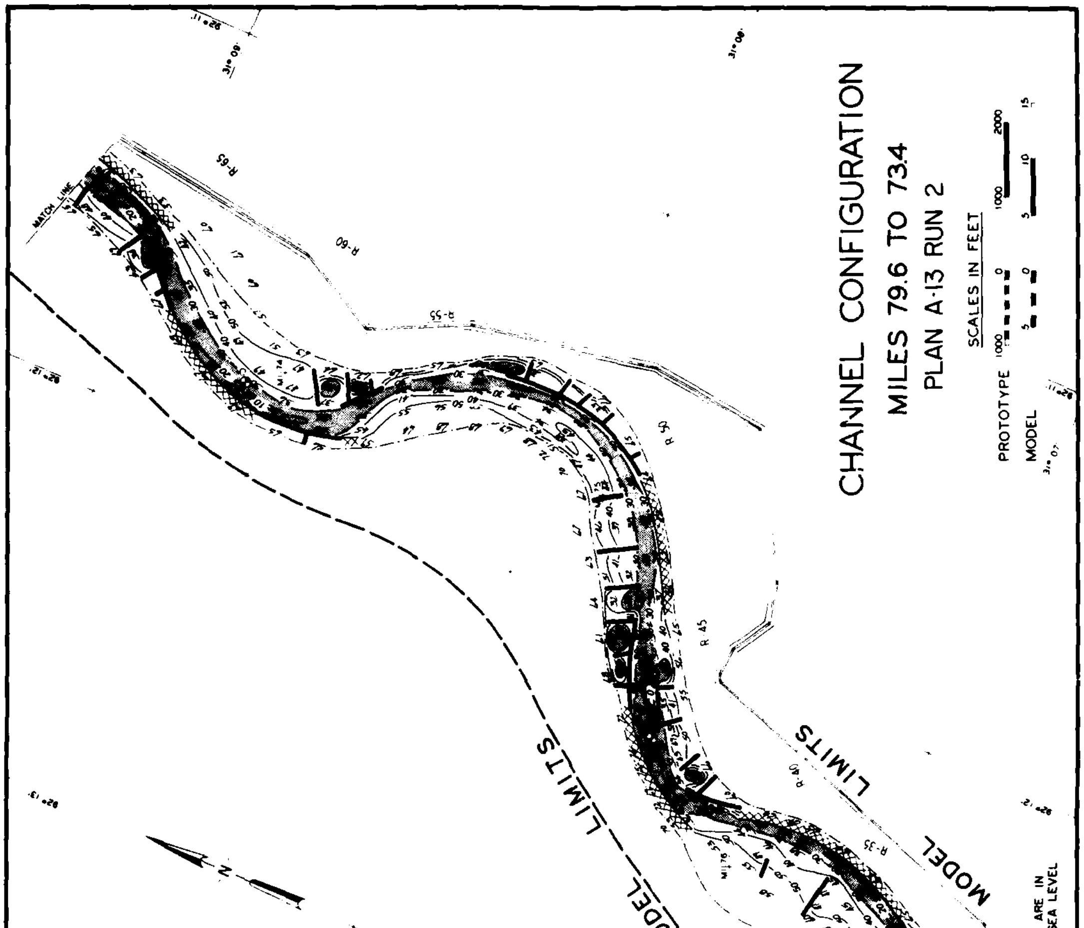
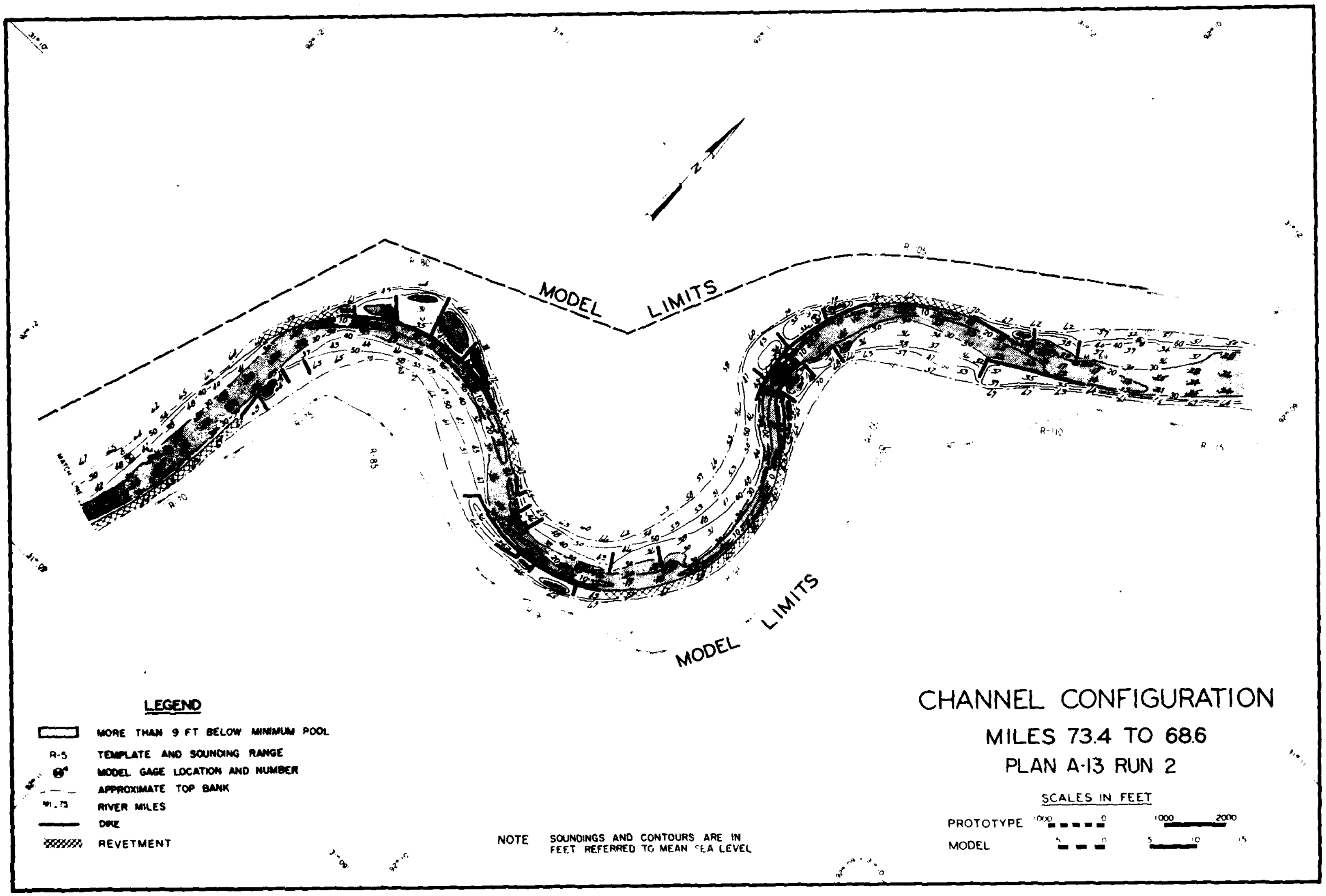

CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
PLAN A-12 RUN 1
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MODEL LIMITS
MODEL LIMITS
MATCH LINE
N
R-80
R-85
R 90
R-95
R-100
R 105
R-110
R 115

PLATE 11



CHANNEL CONFIGURATION
MILES 79.6 TO 73.4
PLAN A-13 RUN 2
SCALES IN FEET
PROTOTYPE
MODEL
MODEL LIMITS
MODEL LIMITS
N
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL

PLATE 12


MODEL LIMITS
MODEL LIMITS
N
R-80
R-85
R-90
R-105
R-110
R-115
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
PLAN A-13 RUN 2
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15

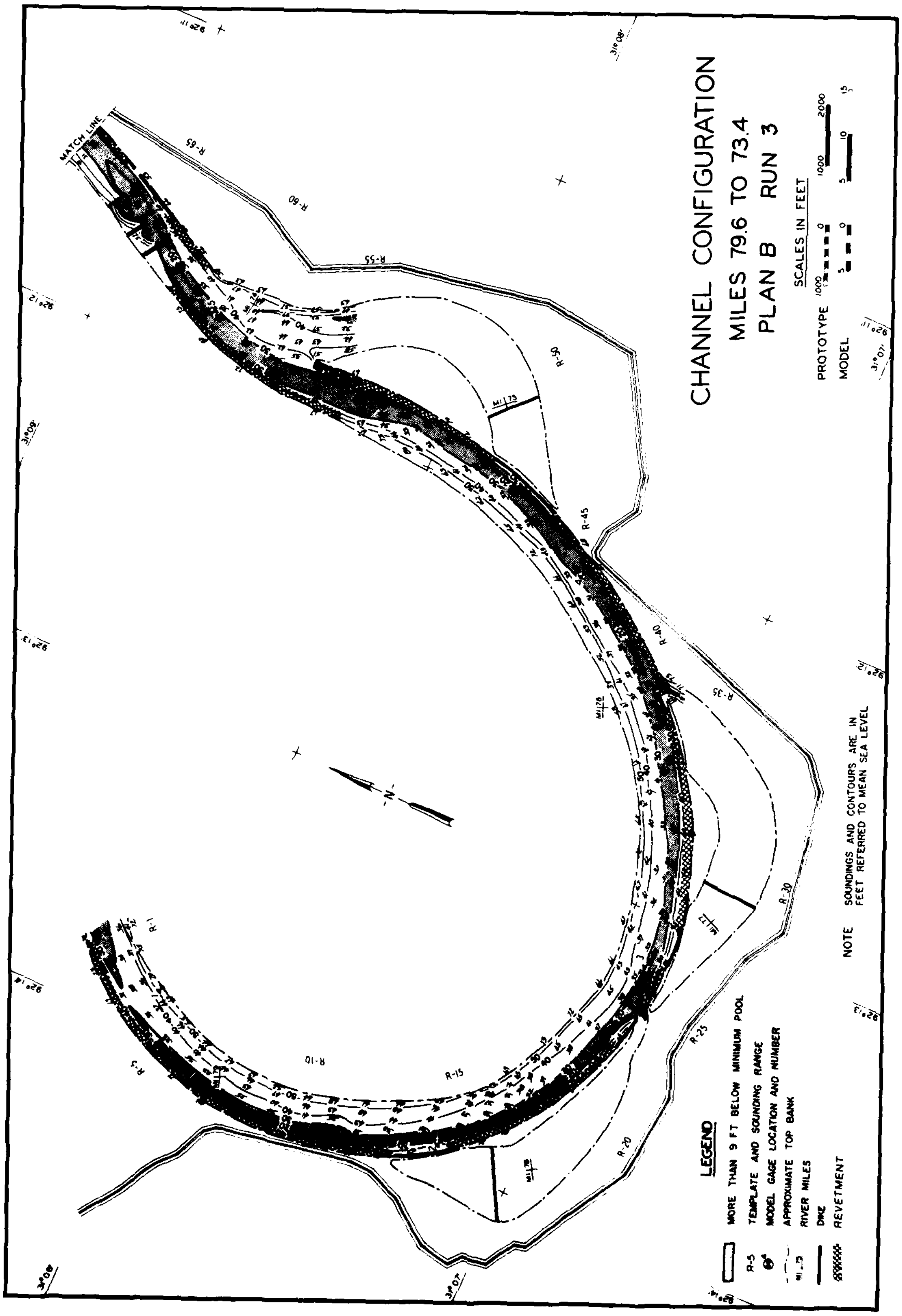

CHANNEL CONFIGURATION
MILES 79.6 TO 73.4
PLAN B RUN 3
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
REVETMENT
MATCH LINE
R-65
R-60
R-55
R-50
R-45
R-40
R-35
R-30
R-25
R-20
R-15
R-10
R-5
R-1
N

PLATE 14

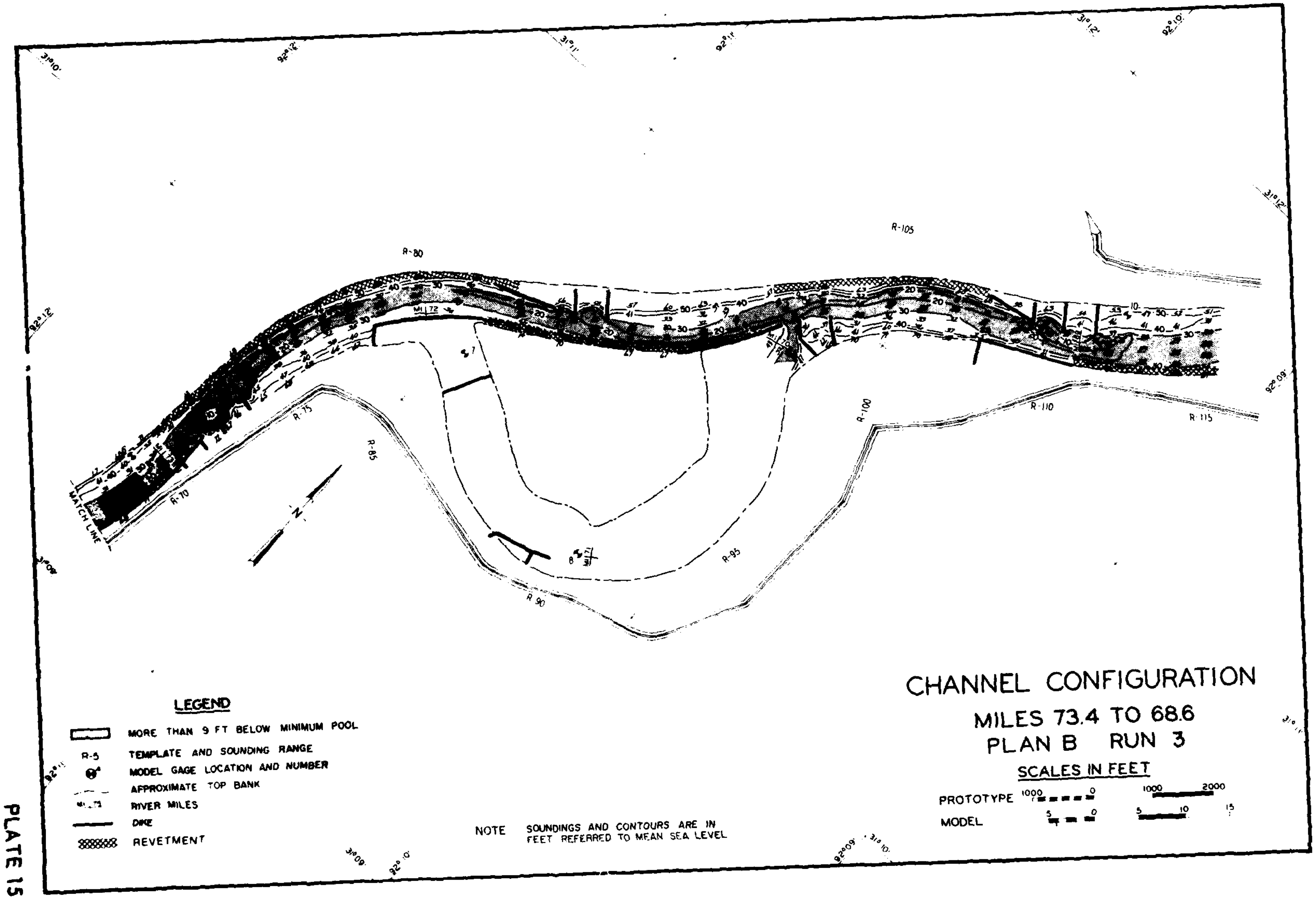

CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
PLAN B RUN 3
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MATCH LINE
R-70
R-75
R-80
R-85
R-90
R-95
R-100
R-105
R-110
R-115
MI 72
N

PLATE 15

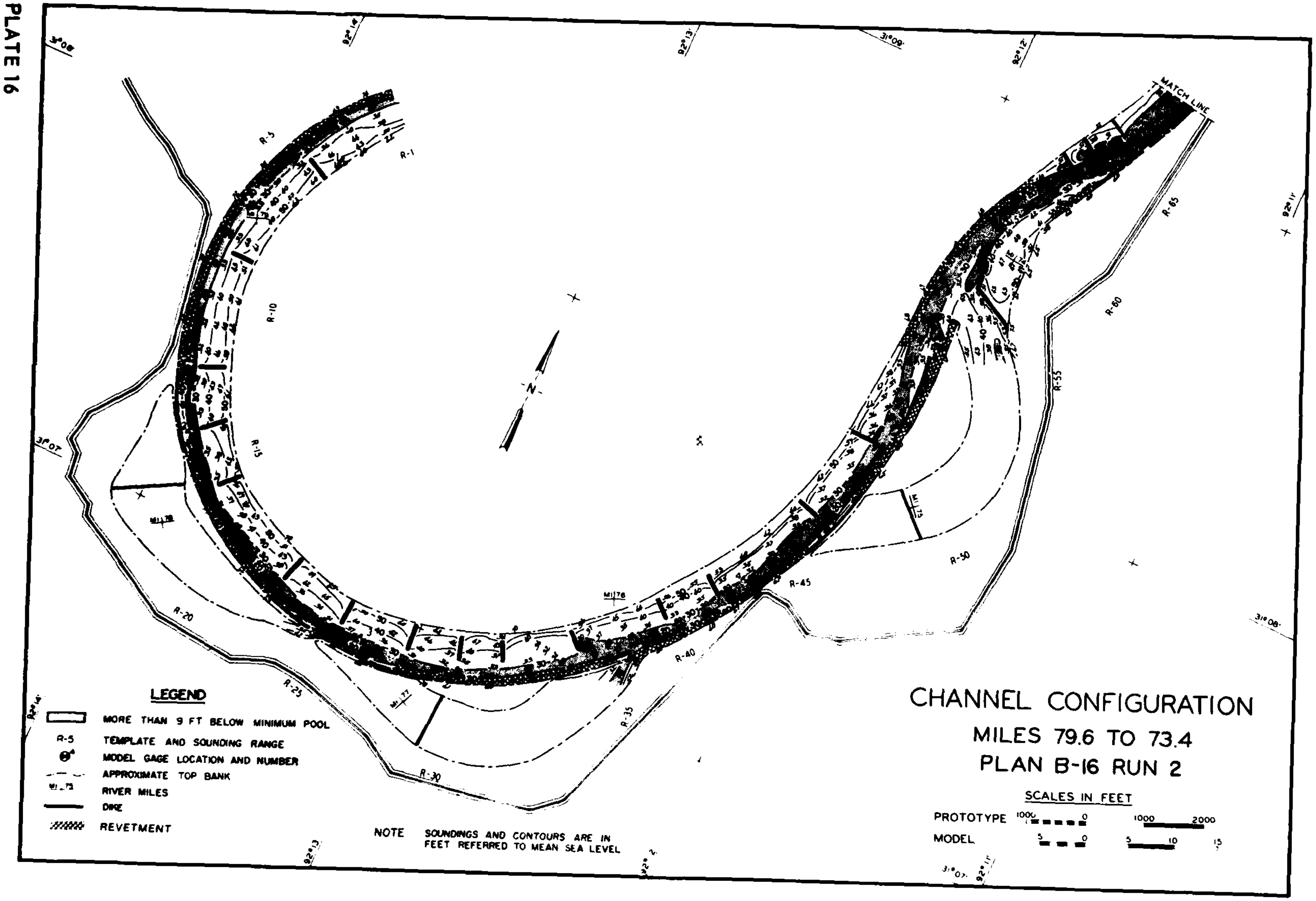
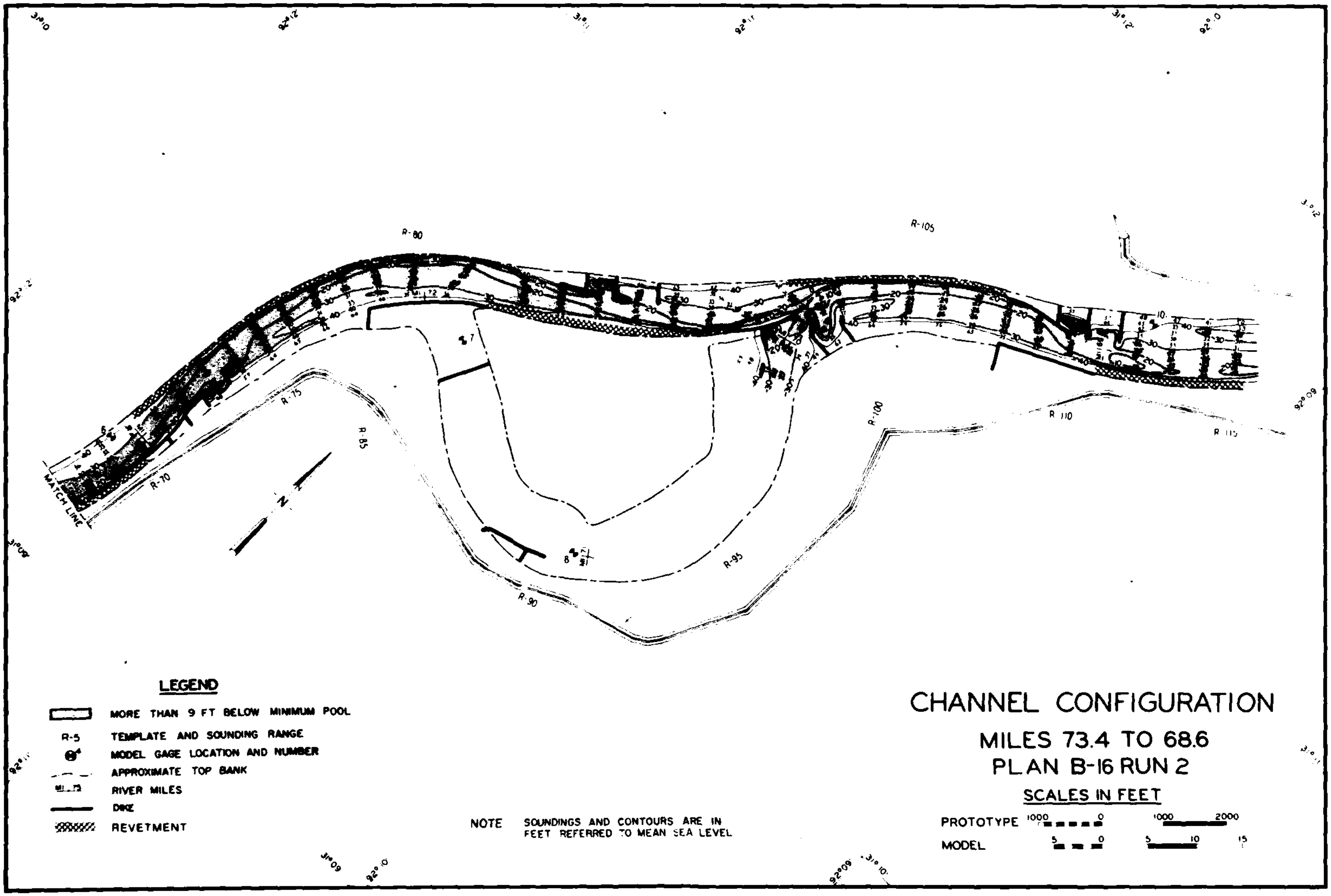

CHANNEL CONFIGURATION
MILES 79.6 TO 73.4
PLAN B-16 RUN 2
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
DIKE
REVETMENT
NOTE SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MATCH LINE
R-1
R-5
R-10
R-15
R-20
R-25
R-30
R-35
R-40
R-45
R-50
R-55
R-60
R-65
MI 73
MI 77
MI 78
31°08'
31°07'
31°09'
92°14'
92°13'
92°12'
92°11'

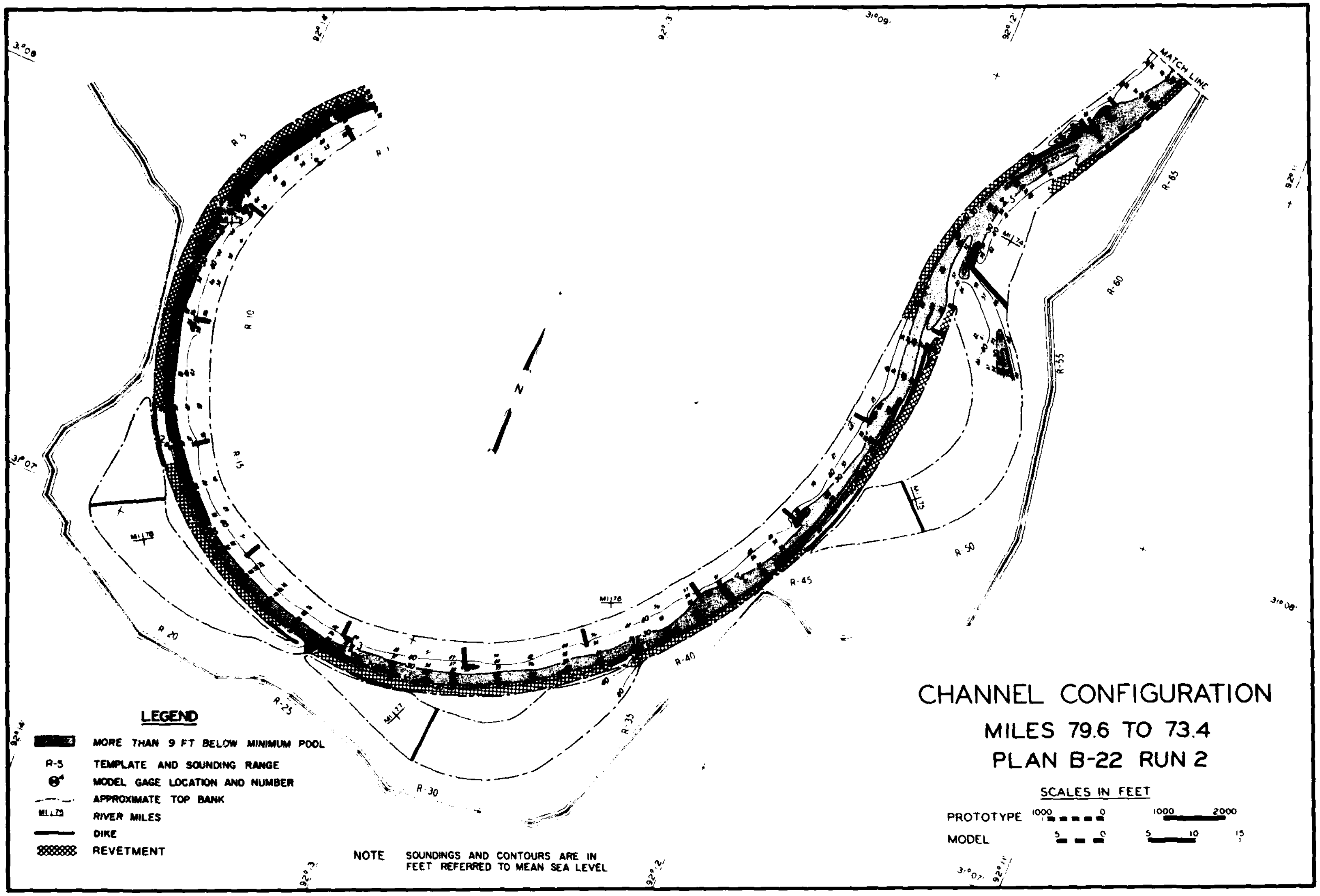
PLATE 16



CHANNEL CONFIGURATION

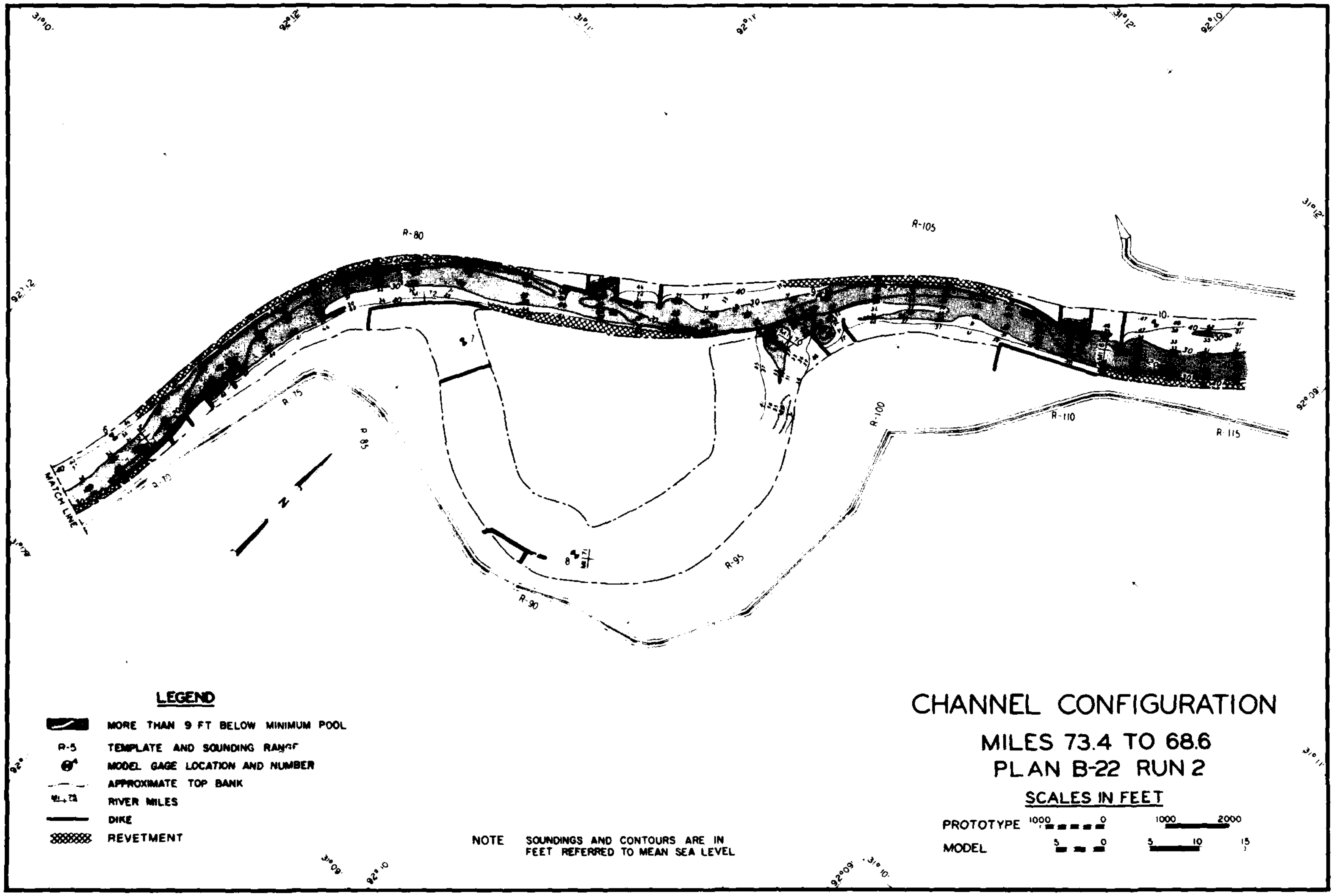
MILES 73.4 TO 68.6

PLAN B-16 RUN 2



CHANNEL CONFIGURATION
MILES 79.6 TO 73.4
PLAN B-22 RUN 2

PLATE 18



CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
PLAN B-22 RUN 2

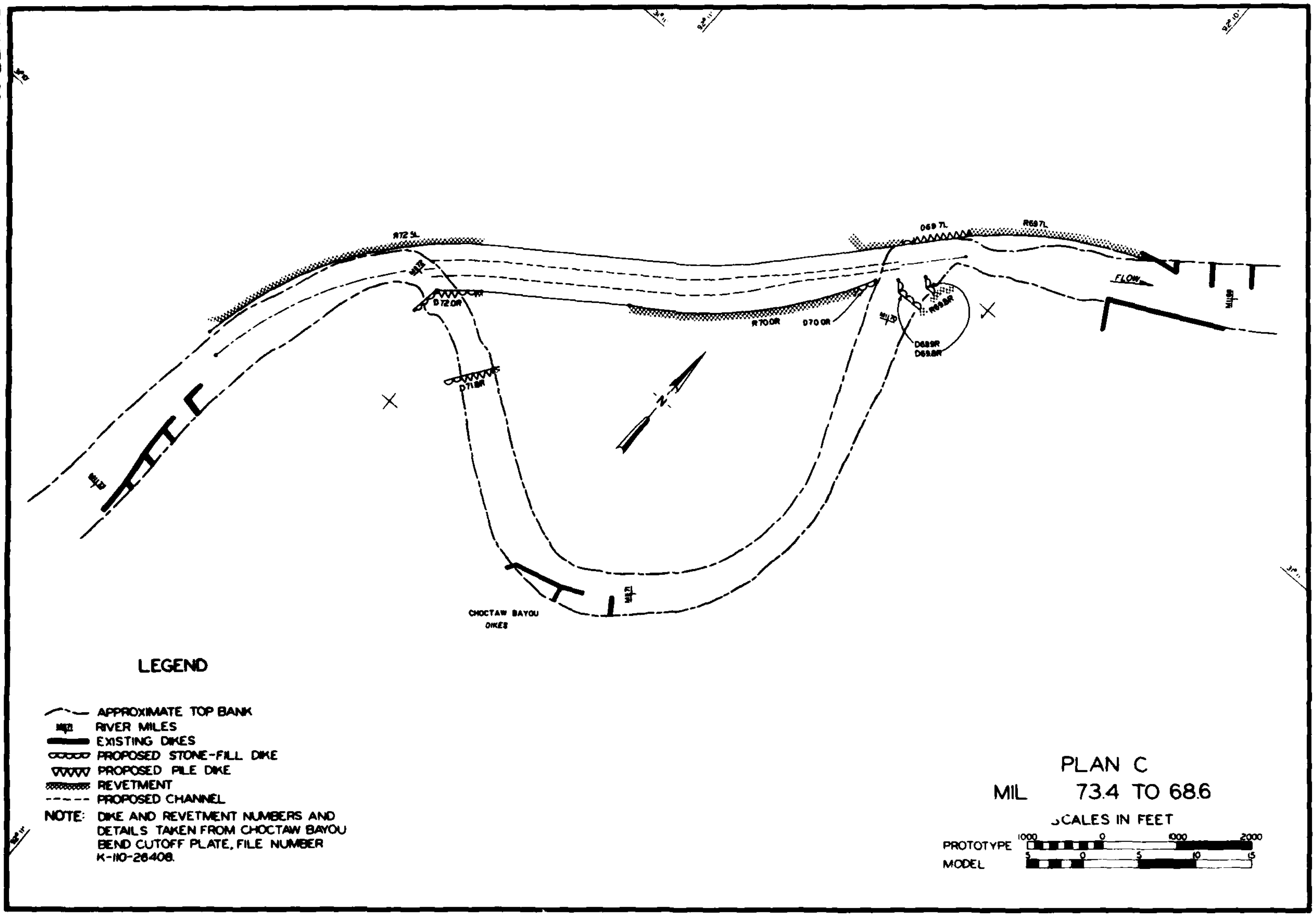
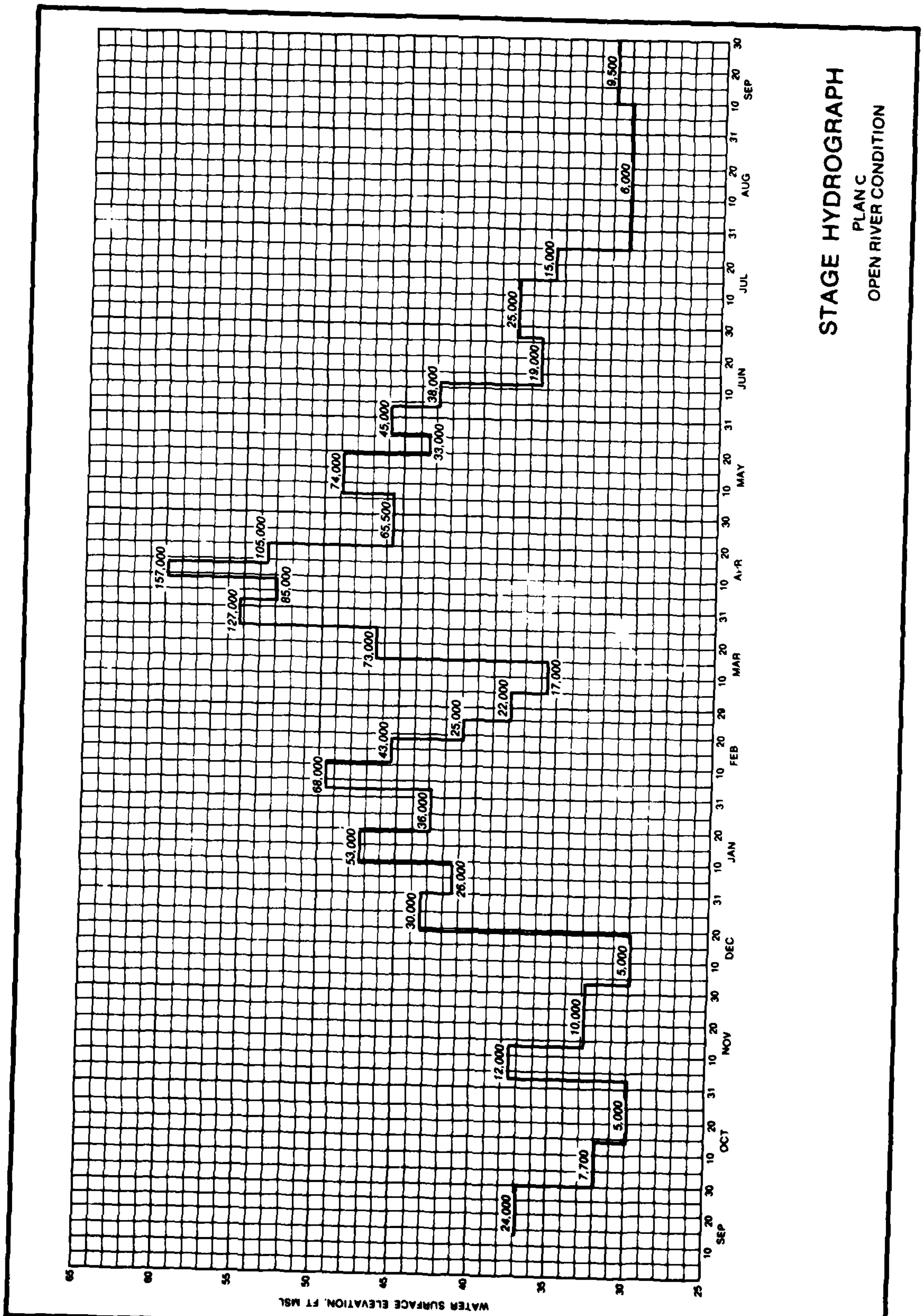

R72.5L
D72.0R
D71.8R
R70.0R
D70.0R
D69.7L
R69.7L
R69.8R
D69.9R
D69.8R
FLOW
CHOCTAW BAYOU
DIKES
LEGEND
APPROXIMATE TOP BANK
RIVER MILES
EXISTING DIKES
PROPOSED STONE-FILL DIKE
PROPOSED PILE DIKE
REVETMENT
PROPOSED CHANNEL
NOTE: DIKE AND REVETMENT NUMBERS AND DETAILS TAKEN FROM CHOCTAW BAYOU BEND CUTOFF PLATE, FILE NUMBER K-110-26408.
PLAN C
MIL 73.4 TO 68.6
SCALES IN FEET
PROTOTYPE
1000
0
1000
2000
MODEL
5
0
5
10
15

PLATE 20


STAGE HYDROGRAPH
PLAN C
OPEN RIVER CONDITION
WATER SURFACE ELEVATION, FT MSL
25
30
35
40
45
50
55
60
65
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
24,000
7,700
5,000
12,000
10,000
5,000
30,000
26,000
53,000
36,000
68,000
43,000
25,000
22,000
17,000
73,000
127,000
85,000
157,000
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65,500
74,000
33,000
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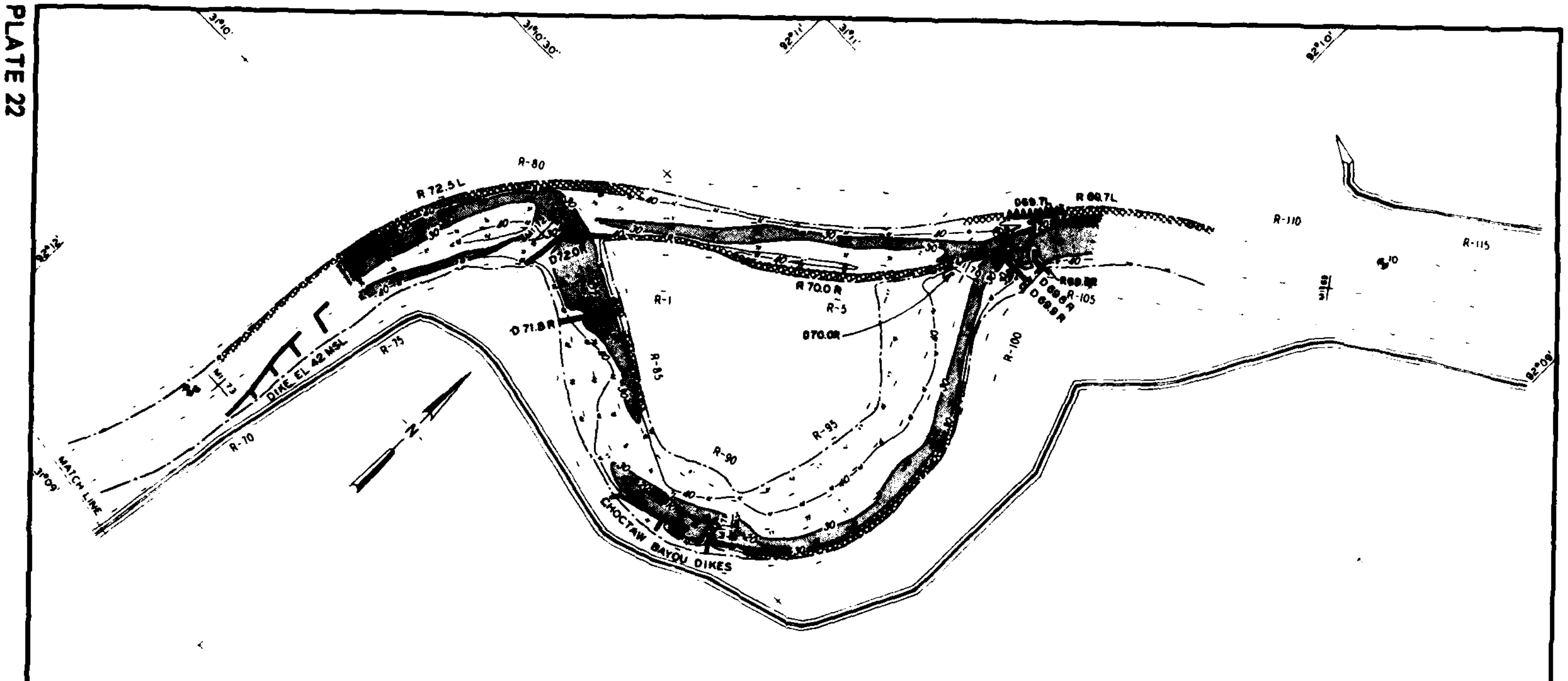
19,000
25,000
15,000
6,000
9,500



LEGEND

- MORE THAN 9 FT BELOW MINIMUM POOL
- R-5 TEMPLATE AND SOUNDING RANGE
- MODEL GAGE LOCATION AND NUMBER
- APPROXIMATE TOP BANK
- RIVER MILES
- STONE-FILL DIKE
- PILE DIKE
- REVETMENT

NOTE: R72.0R AND D71.8R ARE BUILT AS SHOWN ON CONSTRUCTION DRAWINGS (FILE NO K-110-26408)

NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL

CHANNEL CONFIGURATION

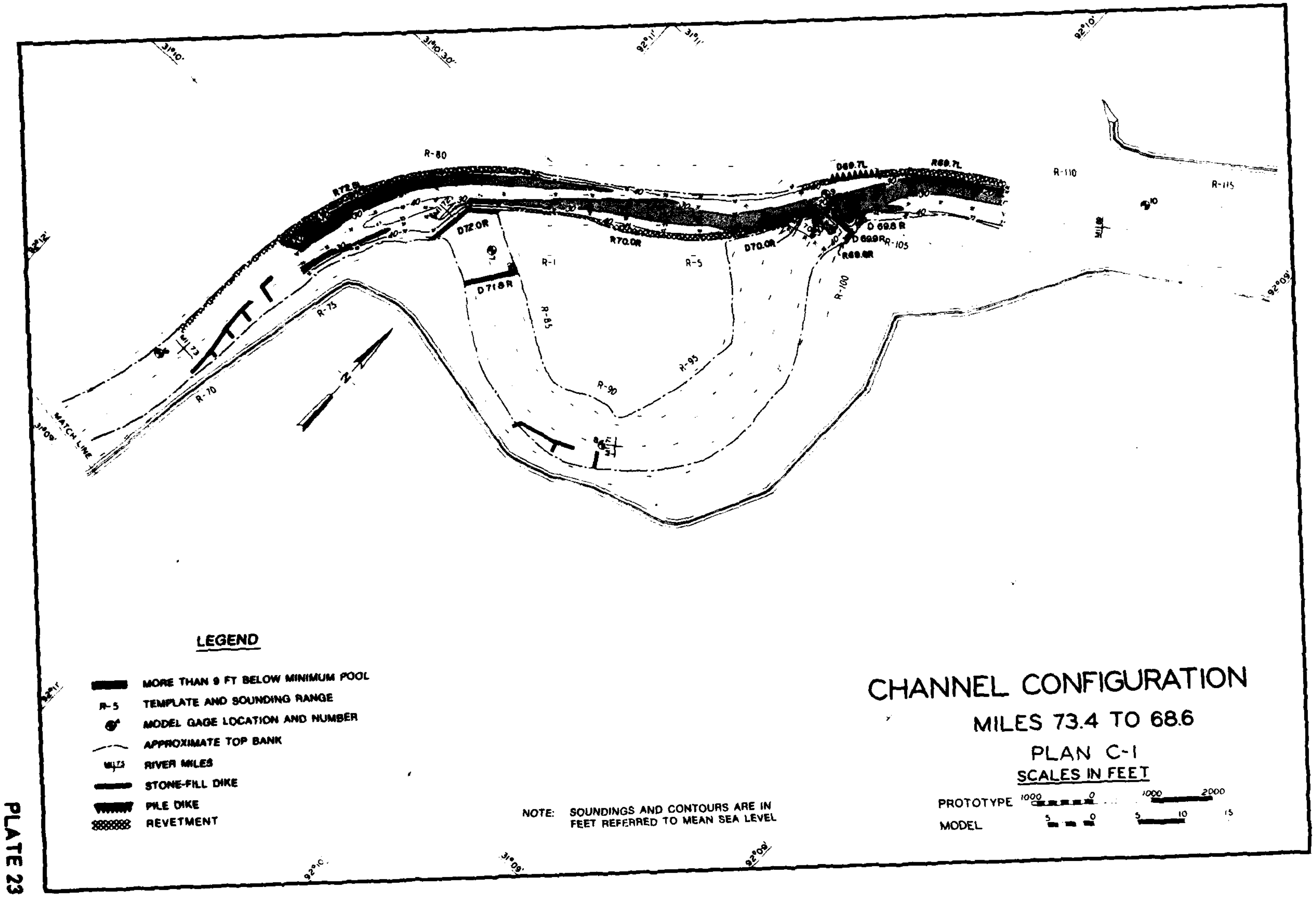
MILES 73.4 TO 68.6

PLAN C

SCALES IN FEET

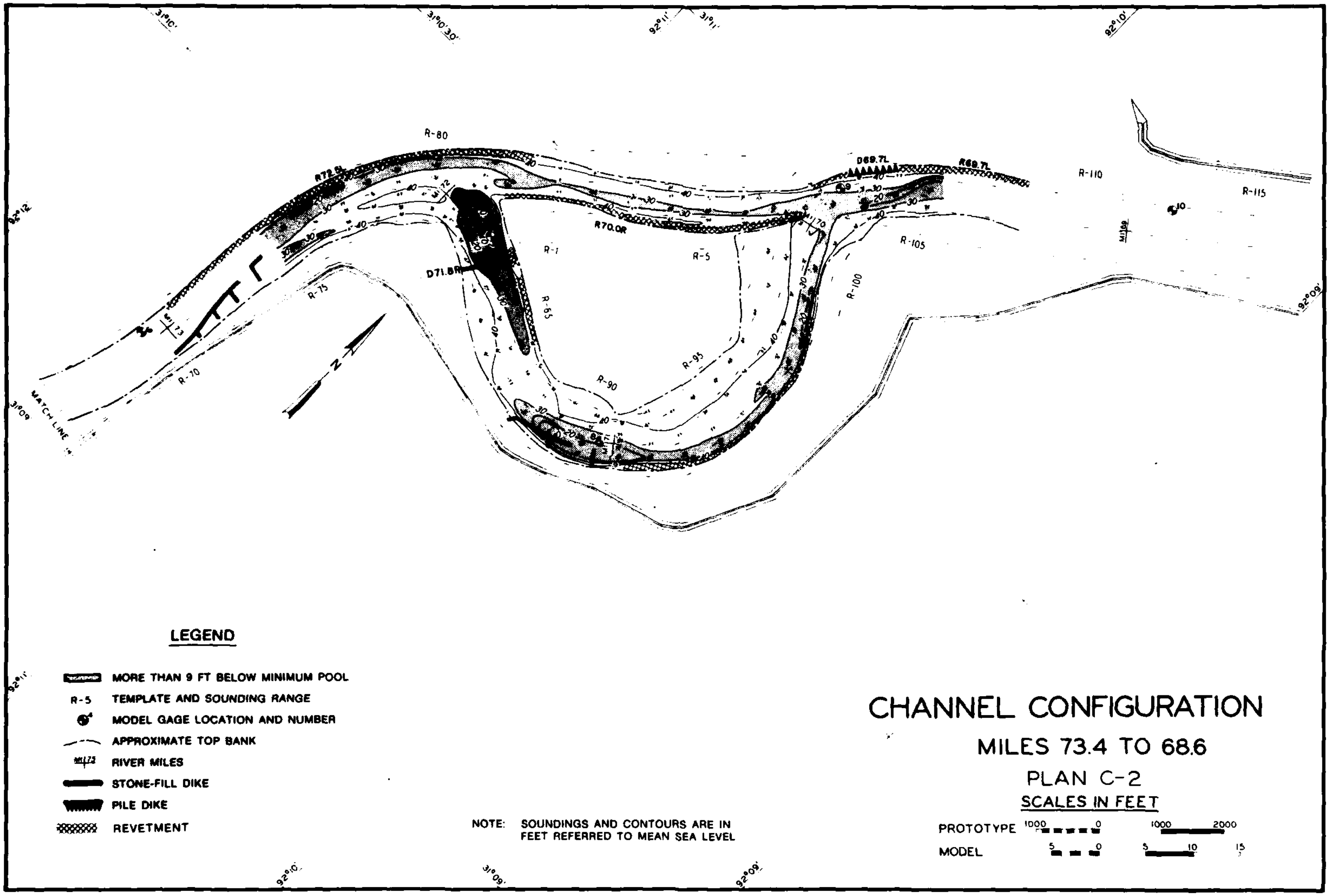
PROTOTYPE 1000 0 1000 2000

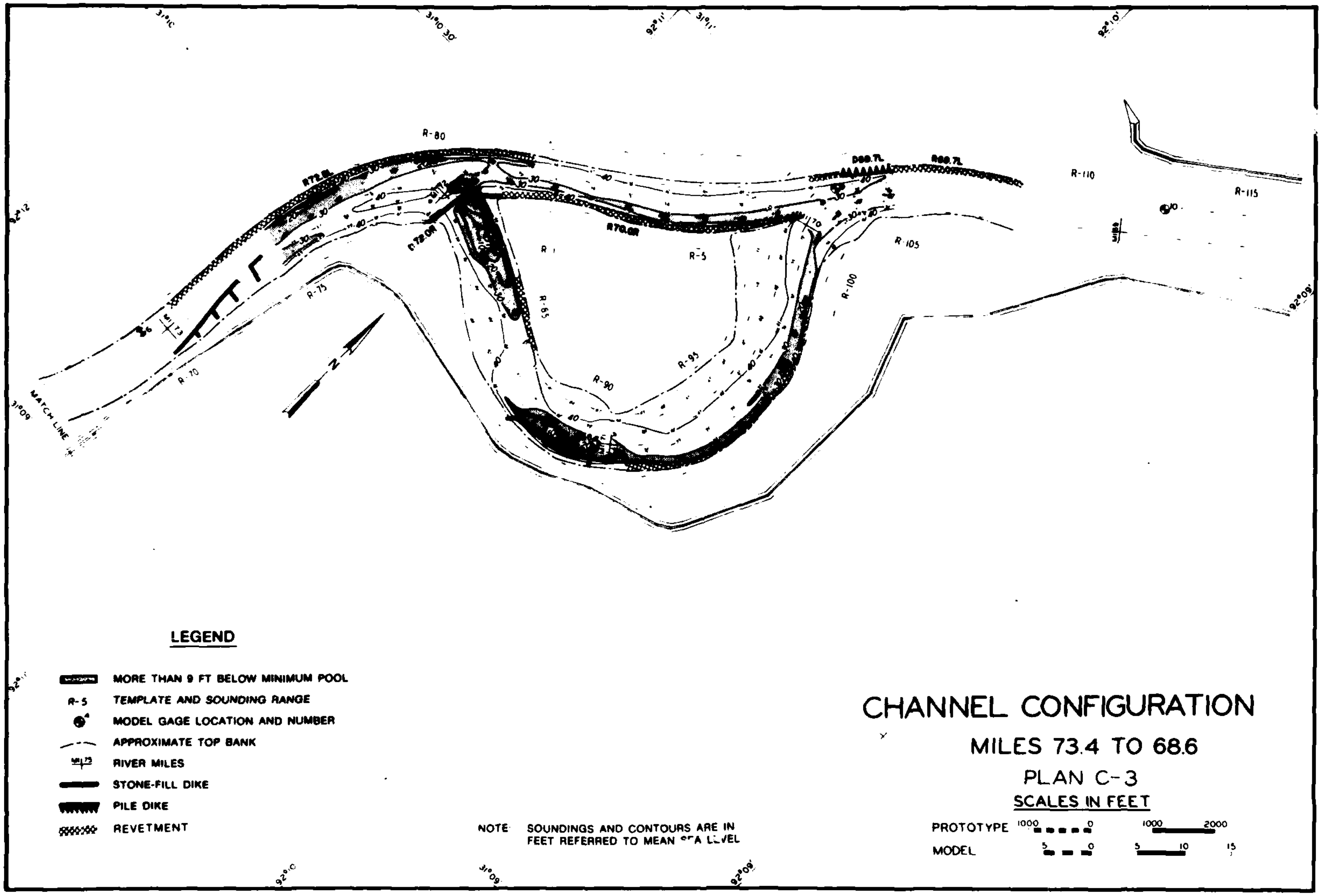
MODEL 5 0 5 10 15



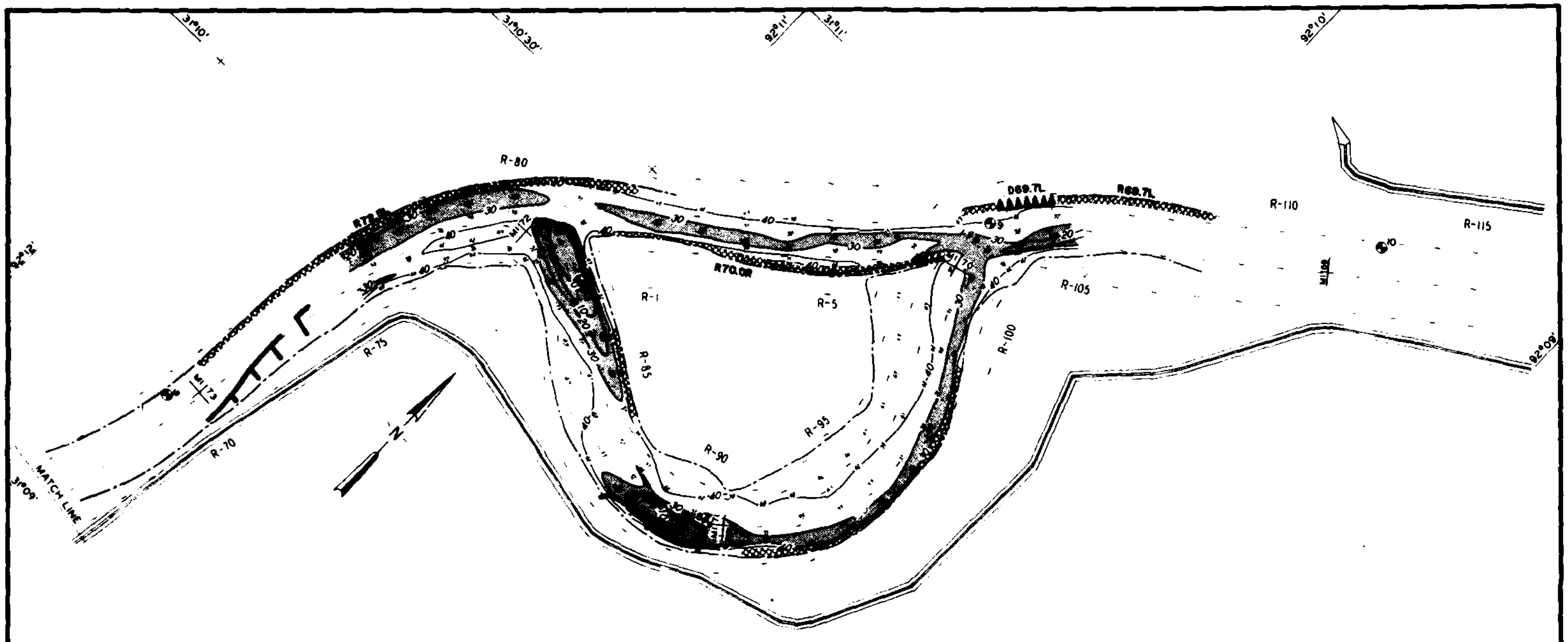
CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
PLAN C-1
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
STONE-FILL DIKE
PILE DIKE
REVETMENT
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
MATCH LINE
R-70
R-75
R-80
R-85
R-90
R-95
R-100
R-105
R-110
R-115
R-1
R-5
R72.0L
D72.0R
D71.8R
R70.0R
D70.0R
D69.7L
R69.7L
D69.8R
D69.9R
R69.6R

PLATE 23


LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
STONE-FILL DIKE
PILE DIKE
REVETMENT
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
PLAN C-2
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15
R-80
R72.9L
R70.0R
D71.8R
D69.7L
R69.7L
R-110
R-115
R-105
R-100
R-95
R-90
R-85
R-75
R-70
R-1
R-5
MATCH LINE



R-70
R-75
R-80
R-85
R-90
R-95
R-100
R-105
R-110
R-115
R-5
R-1
R72.0R
R70.0R
R72.8L
D69.7L
R69.7L
N
MATCH LINE
LEGEND
MORE THAN 9 FT BELOW MINIMUM POOL
R-5 TEMPLATE AND SOUNDING RANGE
MODEL GAGE LOCATION AND NUMBER
APPROXIMATE TOP BANK
RIVER MILES
STONE-FILL DIKE
PILE DIKE
REVETMENT
NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL
CHANNEL CONFIGURATION
MILES 73.4 TO 68.6
PLAN C-3
SCALES IN FEET
PROTOTYPE 1000 0 1000 2000
MODEL 5 0 5 10 15



LEGEND

- MORE THAN 9 FT BELOW MINIMUM POOL
- R-5 TEMPLATE AND SOUNDING RANGE
- MODEL GAGE LOCATION AND NUMBER
- APPROXIMATE TOP BANK
- RIVER MILES
- STONE-FILL DIKE
- PILE DIKE
- REVETMENT

NOTE: SOUNDINGS AND CONTOURS ARE IN FEET REFERRED TO MEAN SEA LEVEL

CHANNEL CONFIGURATION

MILES 73.4 TO 68.6

PLAN C-4

SCALES IN FEET

PROTOTYPE 1000 0 1000 2000

MODEL 5 0 5 10 15

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Foster, James E.
Development and maintenance of typical navigation channel, Red River : Hydraulic Model Investigation / by James E. Foster, Charles R. O'Dell, John J. Franco (Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. : available from NTIS, 1982.
29, [6] p., 26 p. of plates : ill. ; 27 cm. -- (Technical report / U.S. Army Engineer Waterways Experiment Station ; HL-82-6)
Cover title.
"February 1982."
Final report.
"Prepared for U.S. Army Engineer District, New Orleans."

1. Hydraulic models. 2. Channels (Hydraulic Engineering). 3. Navigation. 4. Red River (Tex.-La.) I. O'Dell, Charles R. II. Franco, John J. III. United States. Army. Corps of Engineers. New Orleans District. IV. U.S.

Foster, James E.
Development and maintenance of typical navigation : ... 1982.
(Card 2)

Army Engineer Waterways Experiment Station. Hydraulics Laboratory. V. Title VI. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; HL-82-6.
TA7.W34 no.HL-82-6

DATE
ILME